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## *THE ORIGIN OF GYMNOSPERMS AND THE SEED HABIT.**

### INTRODUCTORY.

THE most difficult as well as the most fascinating problem in connection with any group is its phylogeny. The data upon which we base opinions concerning phylogeny are never sufficient, but such opinions usually stimulate research and are necessary to progress. Any statement dealing with this problem is merely an expression of our knowledge of comparative morphology, and of our judgment concerning the phylogenetic importance of certain structures.

To my mind, the most conspicuous error in many schemes of phylogeny is the tendency to focus attention upon very few structures. It may be that the structures selected are the most significant, but the organism is a plexus of structures and must be considered in its totality. Very different structures have been laid hold of by the processes of evolution, and it may not be possible to relate the resulting forms properly upon the basis of any one or two structures. A conspicuous example is furnished by the liverworts, in which one line gave special attention to the structure of its gametophyte body, another to the form of its gametophyte body, a third to the struc-

* Address of the retiring President of the Botanical Society of America, delivered at Boston, August 19, 1897.

ture of its sporophyte body. Any attempt to relate these to one another upon the basis of a single structure, even so important a one as the sporogonium, is essentially misleading. But when we consider the totality of structure we are led to the opinion that these lines possibly diverged from an archetypal plexus in which there were gametophyte bodies as simple as that of Aneura and sporophyte bodies as simple as that of Riccia. Another illustration is the recent attempt of Arnoldi to associate Isoetes with Selaginella largely upon the basis of endosperm development, without regard to great diversities in habit and anatomical details. The association may be perfectly proper, but the reason given for it is inadequate.

In dealing with problems of phylogeny it is also important to remember that the origin of a prominent group of living forms from another group of living forms is extremely improbable. We can point out resemblances in structures which we have come to regard as essential, but this is not likely to mean the origin of the one group from the other. It may mean that the two groups can be traced to one, probably now extinct, which combined the characters now differentiated. Most living groups are best regarded as divergent rather than consecutive series.

But even this apparently sure ground has become very uncertain from the fact, becoming more and more apparent, that similar changes in structure, even very important ones, may have appeared independently in different lines. The response of organisms in structure to their environment is deeper seated than we were once inclined to believe, and testimony from the similarity of certain structures, when contradicted by the majority of other structures, argues feebly for recent community of origin. Such similarities in structure argue more for physiological conditions than for phylogeny. For instance, from the standpoint of evolution, the appearance of heterospory among the pteridophytes is one of the most important contributions to plant progress made by the group, but it is impossible to escape the conclusion that heterospory was attained independently by several lines. To put into the same genetic group all heterosporous pteridophytes would be regarded as a morphological absurdity. If heterospory appeared independently in several lines the same conclusion must be reached in reference to its natural outcome, the seed, and the polyphyletic origin of the spermatophytes becomes extremely probable.

This increases the perplexities of phylogeny, but it broadens its horizon and introduces another possibility. To continue the same illustration, in our search for the origin of seed-plants we have narrowed attention to the existing heterosporous pteridophytes, when some of the spermatophyte groups, as, for example, the gymnosperms, may represent an entirely distinct line in which heterospory and then the seed appeared, and may not be related directly to any existing heterosporous pteridophyte. In such a case we are permitted to look to some group of living homosporous pteridophytes as possibly containing the best living representatives of the group from which gymnosperms have been derived.

With all these possibilities in mind, I wish to discuss the phylogeny of the gymnosperms, not so much to reach a clear phylogeny as a clearer understanding of the complexity of the problem and the uncertainty of conclusions. This is a field in which no one can afford to be dogmatic.

### THE ORIGIN OF GYMNOSPERMS.

From Hofmeister's classic researches to the discovery of gymnosperm spermatozoids by Hirase, Ikeno and Webber, the fact has

become increasingly apparent that gymnosperms are very closely related to pteridophytes. It was natural, for a time, to regard gymnosperms as phylogenetically intermediate between pteridophytes and angiosperms, for it was not easy to believe that such a structure as the seed appeared in more than one genetic line; but it is probably not going too far to say that there is now no serious opposition to the view that the gymnosperm and angiosperm lines are genetically independent. However, such a discussion does not lie within the scope of this paper.

That gymnosperms have been derived from pteridophyte stock is hardly open to discussion; at least we must assume that this is true, or all attempts at phylogeny are useless. The first question which confronts us, therefore, is whether the very divergent gymnosperm lines have had a common origin in this pteridophyte stock or not. Was there a single group of archaic gymnosperms, derived from pteridophytes, which subsequently differentiated into distinct lines? The existing gymnosperm groups are so very diverse that one of two things seems evident: either they differentiated into divergent lines from a common gymnosperm stock in very ancient times, or they originated independently from the pteridophyte stock. From this discussion I wish to exclude the Gnetales, as we do not possess sufficient data concerning their early history, or concerning the morphology of the very dissimilar living forms, to justify any opinion as to their origin. They are such dissimilar fragments, living in such extreme conditions, that their origin is totally obscure. In some respects they are more cycad-like than conifer-like, but in most respects they are so unlike both that a separate origin seems possible. It may be even true that the three genera belong to groups of independent origin, which is certainly the easiest way of disposing of their differences; and their common characters of true vessels, the so-called perianth and elongated micropyle, may have been attained independently as readily as heterospory; but the combination of characters in common does not seem to justify such a disposition of them, and the three genera had better be regarded as of common derivation, wonderfully diversified by ancient separation, isolation and extreme conditions.

Approaching the subject from the historical standpoint, the group Cordaites seems to be the first with sufficient data to justify consideration. The structure of the vascular bundles, especially those of the leaves, is said to suggest those of conifers, cycads, Isoetes and Ophioglossum; and the sporophylls are organized into a strobilus, a character common to pteridophytes and gymnosperms. But such characters can be used only as cumulative testimony. In such evidences as we have of the structure of the male gametophyte, however, we obtain some valuable suggestions. Within the mature microspore there appears a considerable group of polygonal cells. In living groups of gymnosperms, so far as investigated, there is no such structure; and if we look to pteridophytes for suggestion we are constrained to believe that this group of cells is either prothallial or sperm mother cells. In either event, it would represent a condition of things much nearer pteridophytes than is shown by any living seed plant. In view of the discovery of spermatozoids in Cycas, Zamia and Ginkgo, taken in connection with the peculiar structure of the male gametophyte just described, I am of the opinion that the Cordaites also developed spermatozoids. With either hypothesis as to the nature of the cells developed within the microspore of Cordaites, in seeking for the pteridophyte origin of the group, we are led away from such heterosporous pteridophytes as now exist, for in them the male gametophyte is much more reduced

than in Cordaites—in fact, more reduced than in most living cycads and conifers.

Additional testimony to the same effect is furnished by sections of the seeds of Cordaites. In addition to the remarkable nucellus beak, which probably has no phylogenetic significance, the large pollen chamber is a conspicuous feature. This is sometimes so extraordinarily large that it occupies the whole upper portion of the nucellus, and has been observed to contain numerous pollen grains. The pollen chamber is a well-known cycad feature, and seems to be associated with the early development of siphonogamy. By means of it, the tubular outgrowth from the antheridium wall is reduced to a minimum, and may coexist with spermatozoid development, as shown by Hirase, Ikeno and Webber.

The testimony all indicates that in Cordaites we have the beginnings of a siphonogamic line, brought about by the retention of the megaspore, which still develops its exine in Cordaites and some cycads.

As to the pteridophyte group from which the Cordaites were derived, data are not sufficient to make opinion other than a pure hypothesis. I think it is clear that such heterosporous pteridophytes as are living to-day must be set aside in this search, by the testimony of both of their gametophytes, especially the male. They stand for lines which have very much reduced the male gametophyte, have variously modified the female gametophyte, but have not developed siphonogamy by retaining the megaspore. It may be that the lycopod forms of the Carboniferous and earlier formations represent the pteridophyte plexus from which Cordaites were derived, but we know too little of their morphology to make any assertion. My judgment is that the Cordaites represent an independent heterosporous line, and that if they were associated in origin with the lycopod forms at all it was before the latter had developed heterospory, which seems never to have been extensively developed in the lycopod line until recent times.

I believe that we must regard either the ancient homosporous lycopod forms or the abundant Palæozoic Marattia forms as responsible for the origin of Cordaites, and my own inclination is toward their Marattia origin, perhaps for no better reason than that in such an origin I see more opportunity for the development of such a group as cycads; but such a view is further supported by the discovery that the spermatozoids of cycads, and their ally, the Ginkgo, are of the multiciliate type, and not biciliate, as in living lycopod forms. Just what stress should be laid upon this I do not know, but when opinion is fairly balanced it would seem to help to a decision. It seems satisfactory, therefore, to regard the origin of cycads as from the homosporous-eusporangiate plexus of Filicales, represented to-day most abundantly by Marattia and its allies. It would seem, further, that this has been brought about without the intervention of such Cordaites as we recognize, which, with probably similar origin, were developing a very different type of body, which finds its modern expression in the conifers. In the acknowledged Cordaites, therefore, I recognize a transition region between the homosporous-eusporangiate plexus of Filicales and the more modern conifer series; while in the cycads we have a line which continued more of the fern habit and structure, recognizable not merely in its foliage leaves and general port, but in its occasional vascular bundles of concentric type and its multiciliate spermatozoids. The Cordaites, however, must have included forms that we have not recognized as such, for it is only when they become differentiated from the fern habit that in the main we are able to distinguish them. This very fact of their sharp differ-

entiation means that they had made a decided departure, and we are probably able to recognize only the most highly specialized forms. Of course, in what I have said I may have been using the name Cordaites in a much more inclusive sense than taxonomy would justify. As ordinarily defined I would see in them the first distinct beginnings of a type which afterwards gave rise to the conifers; as used in this paper they refer to a plexus of forms derived from the homosporous-eusporangiate Filicales which gave rise to both cycads and conifers as divergent lines, one retaining more nearly the fern habit and structure and culminating earlier, the other departing more widely from the habit and structure and culminating later. I believe that some Palæozoic forms now regarded as ferns will be found to be more closely related to the Cordaites. How many other lines arose from this large Cordaites plexus, as I have defined it, we have no means of knowing, but it seems to be responsible at least for all of the living gymnosperm forms.

It is important to obtain such historical evidence as we can in reference to the gymnosperm lines, restricted in this paper to the Cordaites, conifers and cycads. If a historical sequence can be established which conforms to the views expressed here as to the interrelationship of these lines the conclusion will have additional support. I need not apologize for the paucity of data furnished by paleobotanists. They have done what they could, and we are greatly in their debt. Morphologists recognize, however, that the structures usually preserved are not the most convincing as to relationships, and that nowhere are appearances more deceitful. While we have no sympathy with wild generalizations based upon fragmentary material, there is an increasing accumulation of data which furnishes a substantial foundation for some conclusions. It seems to be clear that during the Palæozoic there was an increasing display of gymnosperms. The fragments which bear this testimony became very abundant in the later periods of the Palæozoic, and are regarded, for the most part, as Cordaites. Associated with these forms is the great display of Marattia and its allies. A distinct type of leaf and of stem is attributed to each of these great groups, and when seeds or sporangia are associated with them the case seems clear enough, but apart from such association the uncertainty is profound. Intergrading forms between the two are to be expected, but with material so fragmentary and non-committal it would be a rare chance that would lead to its definite demonstration. In the Coal Measures the cycad type becomes apparent, but not prominent. This would seem to indicate either an early differentiation from the Cordaites plexus or a late differentiation from the Marattia plexus. I see no difficulty in the former view, as I see no advantage in multiplying the independent heterosporous and seed lines until forced to do so by incontrovertible evidence. The domination of cycads during the Mesozoic and their subsequent decline are well-known facts.

More suggestive, however, is the history of the conifers. It is generally stated that this line, in its modern expression, began during the Palæozoic, and that our modern genera have been recognized by stem and leaf anatomy. Such methods of determination we know to be untrustworthy, as there is the greatest possible amount of anatomical diversity even in contiguous regions of the same organ, much more in different organs and at different ages. In examining the claim that modern coniferous genera appeared during the Coal Measures, I find no evidence that seems to be worthy of serious consideration excepting that with reference to Ginkgo, and it is an interesting fact that Ginkgo is no longer regarded

as a conifer. Long before the evidence of spermatozoids was discovered it seemed perfectly clear to me that Ginkgo was more cycad-like than conifer-like. In the light of our present knowledge the appearance of Ginkgo in association with the Carboniferous cycads seems natural enough. It is a matter of very secondary importance whether we are to regard it as an independent line or not. I am inclined to believe that, while during the Palæozoic heterospory and the seed were both attained, siphonogamy was in its beginnings, and that the spermatozoid habit was for the most part still continued in the seed line. There is no conclusive evidence, therefore, that any of our modern coniferous genera appeared during the Palæozoic, during which the Cordaites were the dominating seed plants. During the last Palæozoic periods undoubted conifers did appear, and in considerable abundance, and we may recognize the beginnings of distinct lines represented to-day by Abies and its allies, Taxodium and its allies, and Taxus and its allies, but the genera are not those of to-day. In the lower Mesozoic, however, modern araucarian and abietinous genera appear; and the Taxodium and Taxus lines become more distinct, but not modern until the later Mesozoic. At that time Cupressus forms also appear, but not of modern genera. Further details are not necessary, as the point to be made is that the conifer type was not recognizable until late in the Palæozoic, and then not in its modern expression. It certainly suggests a later departure from the Cordaites stock than do the cycads.

Another fact is interesting to note in connection with the evolution of the conifer forms. In existing conifers there is considerable variation in the development of the male gametophyte. In some forms, as the Abietineæ, the development of two or three prothallial cells, distinct from the large antheridial cell, is a well-known fact, an amount of prothallial development not shown by any other living heterosporous forms, even the heterosporous pteridophytes. In other forms, as Cupressineæ and Taxeæ, the reduction of the male gametophyte is greater, no sterile prothallial cells appearing, the whole structure being an antheridium, as in the angiosperms. Our historical evidence accords with this progressive reduction of the male gametophyte, the Taxus and Cupressus lines having attained modern expression after the Abies line; and back of the Abies line we find the Cordaites, with probably a still greater development of the sterile region of the male gametophyte indicated. To derive the Cordaites or Abies lines, with their two or three to many-celled sterile tissue of the male gametophyte, from such heterosporous lycopod forms as we know to-day, with their constantly more reduced male gametophytes, is not within the bounds of probability. Besides, the reduction of the male gametophyte seems to be so prompt a response to heterospory that its partially reduced condition in certain conifers, and probably in Cordaites, would seem to argue for their near derivation from some homosporous type.

The development of a suspensor in the lycopod forms has also suggested a genetic connection with gymnosperms, in which the suspensor development is so conspicuous. This organ, however, seems to have no morphological constancy. In gymnosperms it may be developed from a plate of cells formed in the oospore, as in most conifers; or from a mass of cells formed basally or parietally in the oospore, as in cycads; or from free cells formed within the oospore, as in Ephedra; or from the elongation of the oospore itself, as in Gnetum; or from the downward elongation of the archegonium, as in Welwitschia. The suspensor, therefore, seems to be a temporary organ of the embryo, of various morphological origin,

intended to relate the embryo properly to its food supply, and not of phylogenetic significance.

The testimony of history and morphology seem to combine in pointing to a very generalized Palæozoic type as the origin of gymnosperms. This type is characterized by its advancement towards seed production rather than by its habit, which must have been extremely varied to have given rise to such types as cycads and conifers. The usually recognized Cordaites show but one tendency of a much more extensive group, for which the name Cordaites may be extended for convenience. Cordaites in this larger sense occur in such association with groups of homosporous eusporangiate Filicales, and approach them so much nearer in the important morphological structures mentioned than they do living heterosporous Filicales, that an independent heterosporous line is suggested. If such be the case, in the passage from the Marattia forms to the Cordaites forms both heterospory and the retention of the megaspore were attained, and probably siphonogamy begun.

### THE SEED HABIT.

The evolution of heterospory seems simple enough. The physiological differentiation of the spores was complete when prothallia became persistently diœcious. This division of labor is to be expected in the case of two such distinct functions as the production of antheridia and archegonia. A prothallium producing both sex organs equally well may be regarded as in a state of equilibrium, an equilibrium which is disturbed by any conditions which favor the production of one sex organ rather than the other, in this case probably nutritive conditions. This disturbance of the equilibrium of a bisexual prothallium would certainly find an expression first in a diœcious tendency, and finally in a diœcious habit. With the habit once fixed the morphological differentiation of spores becomes inevitable, since the nutritive requirements of the two prothallia are so different. The evolution of heterospory seems to be one of the simplest of selective processes, with inequalities of nutrition to furnish the variations. From this point of view it would seem natural to expect that it may have been derived frequently from homospory.

The retention of the megaspore, however, does not seem to be so simple a problem. In a certain sense it is correlated with the reduction of the gametophyte, since retention would not seem practicable until reduction had proceeded far enough to make the gametophyte endosporic. Even greater reduction, however, is attained by the male gametophyte, but the spore is shed. It should be noted that even in the case of the microspore the male gametophyte is usually completely organized before pollination, but the fact remains that reduction does not compel retention. It has seemed to me that this phenomenon is to be explained by Bower's law of sterilization, developed in reference to the strobilus. This law certainly finds expression in the megasporangia of heterosporous pteridophytes, in which the sterilization of mother cells is conspicuous. This method of increasing the nutrition of the fertile cells is too common a phenomenon to need illustration; but it is a tendency that would seem very consistent with the development of megaspores, whose peculiar work holds so definite a relation to abundant nutrition. For this very reason high numbers of microspores may be continued, and a diminishing number of megaspores produced. This would reach its culmination in the production of but a single megaspore by a sporangium, and a proportionate increase in the size of the megaspore. With the development of a single spore imbedded in sterile tissue, shedding becomes not only mechanically

difficult, but meaningless, since the necessity of scattering a brood of gametophytes, to avoid competition, has disappeared. It is further true that the development of such a spore involves nutritive supplies from numerous neighboring cells, and a certain amount of retention becomes necessary for this reason. Still further, the advantage to a single megaspore in being retained, thus securing more abundant outside nutrition during germination, would fix the habit if any selective process were at work. For these various reasons it would seem evident that when the sterilization of a megasporangium had reached its extreme limit, by organizing a single spore, retention is likely to follow sooner or later. If this line of reasoning be true the seed habit might have been developed in any heterosporous line.

With the retention of the megaspore pollination became necessary, but its gymnosperm expression differs in no way from the scattering of aërial spores in all the lower groups. The new feature demanded by the retention of the megaspore, therefore, was not the scattering of the microspores, but the development of siphonogamy. That the first retained megaspores were exposed to the microspores can hardly be doubted, and in such cases we now know that the spermatozoid habit must have been retained, and that no tube, or a very small protuberance of the antheridium wall, was needed to discharge the spermatozoids sufficiently near the oosphere. If chemotropism can explain the guidance of a pollen tube through much intervening tissue it would certainly be sufficient to cause the protrusion of an elastic antheridial wall. In the very few illustrations of Cordaites obtained, the megaspore is but slightly covered by sterile tissue at the bottom of a deep pollen chamber, and a very slight development of tube is necessary. The same condition is continued in the cycads, and thus the habit of siphonogamy may have been gradually built up. As siphonogamy developed, the gradual failure of the sperm mother cells to organize spermatozoids followed, and presently, almost exclusively now in gymnosperms, sperm mother cells are found to function directly as male gametes without further organization.

The secondary results which followed the retention of the megaspore were numerous. The well-known effect of fertilization upon adjacent tissues necessarily involved at least the sporangium, and the seed resulted. The presence of abundant available nutrition and favorable conditions induced the immediate germination of the oospore, which the development of a resistant tissue about the sporangium checked. As a consequence, the development of the embryo was thrown into two stages, the intra-seminal and the extra-seminal.

In the case of the angiosperms, however, another tendency was connected with the retention of the megaspore, namely, the tendency of the sporophyll to enclose the megasporangium, a tendency so evident in such pteridophytes as Isoetes and Marsilea that the direct pteridophyte origin of the group seems more natural than an origin from so specialized a type as the gymnosperms. Given the reduction of spore production to a single megaspore and the persistent enclosure of the sporangium by the sporophyll, and the angiosperm peculiarities follow. The profound effect of these conditions upon the germination of the megaspore is so remarkable, and the intergrading stages are so completely unknown, that there seems to be no clue to the sequence of changes. That an endosporic gametophyte might eliminate the archegonium seems evident, for the tendency is shown among gymnosperms by Gnetum, where oospheres are organized by free endosperm cells. That the reproductive region of the female gametophyte may be organized earlier than the nutritive region, when the

gametophyte is supplied with outside nourishment by the retention of the megaspore, is hinted at among the heterosporous pteridophytes and gymnosperms. These tendencies have found full expression in the angiosperms, where archegonia have disappeared and the reproductive tissue of the female gametophyte is persistently organized before the nutritive tissue. Evidence as to the details of the evolution of this tendency is lacking and may not be in existence, but the tendency has certainly reached a remarkably definite expression. The unvaried appearance and movement of eight free nuclei or cells, and the remarkable fusion of two of them, represent habits so fixed through such an enormous group that they baffle explanation, and argue both for the monophyletic origin of angiosperms, and against their derivation from so divergent a line as gymnosperms.

The earlier evolution of the gymnosperm line is probably to be explained by ecological conditions. The body as a rule is organized to endure extreme conditions. It is certainly not a mesophytic type, and its evolution was certainly not in response to prevailing mesophytic conditions. On the contrary, the angiosperm type is essentially a mesophytic one, with great foliage display, and probably expanded in response to widely prevalent mesophytic conditions. This might explain the habit peculiarities of the two groups, but whether the more recondite morphological differences hold any relation to these or not is too obscure to permit even speculation.

## SUMMARY.

1. A great Cordaites plexus, more extensive than the one usually included under that name, represented the characteristic Palæozoic seed plants.

2. It was probably derived from homosporous-eusporangiate Filicales, represented to-day most abundantly by the Marattia forms and their allies, and was the most common Palæozoic type of Filicales.

3. From it the gymnosperm lines, at least the cycads and conifers, were derived, the usually recognized Cordaites representing a transition stage towards conifers.

4. The frequent independent appearance of heterospory is to be expected, as it probably results from inequalities of nutrition in connection with the development of antheridia and archegonia.

5. The retention of the megaspore, resulting in the seed habit, follows the extreme sterilization of the megasporangium, which is attained with the organization of but one megaspore. With the development of a single megaspore imbedded in sterile tissue shedding becomes mechanically difficult, unnecessary, and even disadvantageous from the standpoint of nutrition.

6. The retention of the megaspore was followed by the development of seed coats, possibly through the well-known effect of fertilization upon adjacent tissues; by immediate germination of the oospore, on account of the favorable conditions and the abundant supply of available nutrition; and by the checking of the developing embryo by the mature seed structures, resulting in the characteristic intra-seminal and extra-seminal stages of germination.

7. The first retained megaspores were doubtless directly exposed to the microspores, and in Cordaites and cycads a pollen chamber of varying depth and extent is associated with the early stages of siphonogamy, with which the spermatozoid habit was more or less associated.

8. The pollination of gymnosperms is but a continuation of the ordinary method of dispersing aërial spores employed by cryptogams, the chief result of the retention of the megaspore upon the male gametophyte being the development of siphonogamy.

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## THE DEVELOPMENT OF PHOTOGRAPHY IN ASTRONOMY (II.).*

The great nebula of Andromeda has been known to astronomers for upwards of a thousand years, as it is a rather noticeable object with the naked eye. It has received its full share of attention ever since the invention of the telescope. It also appears to be a vast body of gaseous matter shining far away in the depths of space, but it seems to be in a different condition from that of the great nebula of Orion, for its spectrum is continuous and does not show the bright lines, indicating an incandescent gas, which are present in the spectrum of the Orion nebula. Though the mystery of its physical condition has not yet been solved, photography has at least shown us its true form. It has ceased to be the long spindle-shaped body of the elder Herschel, or the broad irregular object, with two dark parallel channels in one side, as drawn by the Bonds and Trouvelot. The photographic plate reveals to us in their place a beautiful symmetrical mass of nebulous matter, surrounded with several more or less concentric rings, claimed by some astronomers to be a representation of the nebular hypothesis of La Place in full operation. The first picture to show the true form of this wonderful object was taken in 1885, with a 20-inch reflector, by Roberts. It does not, however, require a powerful photographic telescope to show its peculiar features, for a 6-inch portrait lens will show the rings well with anything above one hour's exposure.

Important photographs of some of the spiral nebulæ, and especially of the 'whirlpool nebula' of Lord Rosse, were made as early as 1888, by von Gothard, with a 10-inch reflector. Excellent photographs of these objects have also been obtained by Dr. Roberts.

While it is absolutely necessary to use a considerable photographic telescope for the accurate registration of star positions, etc., where measures of precision are required, there are a great number of objects in the sky which are not necessarily subject to measurement, and which for their greatest value require a simple pictorial representation. The Milky Way, one of the most beautiful and certainly the most stupendous of the celestial features, is not susceptible of accurate measurement. The individualizing and measurement of all its stars would be the most hopeless task imaginable. Nor would such a task be of any very great importance could it be accomplished as a whole, for we could not form any special idea of its structural peculiarities from such a work. Though a conspicuous object to the unaided eye, the view we thus get of it is not sufficiently tangible, from the lack of details, to enable one to form any more than a crude idea of its coarser features. But even the naked-eye view of it is far more comprehensive than a catalogue would be containing accurate determinations of all its individual stars. What is required, therefore, in the study of this wonderful object—this mighty universe of stars—is something that will increase the penetration of our vision, and at the same time give us a certain amount of accuracy of position with a large field of view, so that we may study its peculiarities of structure in detail, and at the same time closely locate these details with reference to the whole, and thus, by finally putting structure and detail together, form a comprehensive idea, not only of the details themselves, but also of the relation of these features to each other. The long-focus telescope with a very limited field is not capable of dealing with the Milky Way in the manner stated. Its structural details are very large, far larger

*Address of the Vice-President before Section A—Mathematics and Astronomy—of the American Association for the Advancement of Science, August 22, 1898.

in general than the field of view of the ordinary photographic telescope, and vastly greater than that of a powerful visual telescope. We want, therefore, a short focus instrument, one capable not only of taking in a wide part of the sky, but also of giving a brilliant image, or, in other words, the reduction of the large details to a smaller scale, with a correspondingly great increase of effective light-power. These conditions exist in the large portrait lenses which were needed in the early days of photography to reduce the exposure time by collecting a great quantity of light from the object, and which in these days of rapid dry plates are no longer required for portrait work. Taking in some ten or twelve degrees of the sky, these lenses are specially suitable for photographing large surfaces, such as are presented by the Milky Way.

This subject was taken up by the writer in the first part of 1889 at the Lick Observatory, with a large 6-inch portrait lens of 31 inches focus, and with it was inaugurated the photography of the Milky Way. The first picture to show the real structure of the Milky Way was made in 1889, with this instrument. In the few following years a large series of photographs of those portions of the Milky Way seen from the northern hemisphere was made. The work with similar instruments was next taken up by Dr. Max Wolf, in Germany, who has also succeeded in making excellent pictures of the Milky Way. Mr. Russell, of Sydney, New South Wales, has also photographed portions of the southern part of the Milky Way, with a large portrait lens. Those who have seen some of the Milky Way photographs taken with the regular Astro-Photographic telescope, or who have tried to make out its complex structure with a visual telescope, must be struck with the great beauty of a photograph made with one of these short focus portrait lenses. The extraordinary complexity of structure of the Milky Way is brought out with marvellous beauty of detail, and the peculiarities of its different portions can be traced and connected in the different photographs, which thus afford the most direct means for studying every feature of structure and detail. These pictures show many peculiarities which must materially alter our ideas of the constitution and structure of the Milky Way. Some of them show strong evidence that the general body of the Milky Way may be made up of small stars which are not at all comparable with our sun in dimensions. This is especially shown in the region of the star Rho Ophiuchi. Many parts of the Milky Way appear to be comparatively thin sheetings of stars with relatively no very great depth, for it is not possible otherwise to explain the black holes and rifts shown in them. One of the most important revelations made by the portrait lens in connection with the Milky Way is the presence in it of very diffused nebulous matter apparently freely mixed with the groundwork of stars, and seemingly showing no definite tendency to condensation about the individual stars. These photographic nebulosities of the Milky Way are apparently of a different nature from the ordinary nebulæ of the sky, since they are extraordinarily large, diffused and but feebly luminous. These nebulous regions seem to be peculiar to the Milky Way and its vicinity, and are certainly in some way physically connected with it. It will be in the study by photography of such regions that we shall finally clear away some of the mysteries of the Milky Way. These masses of diffused nebulosity mainly affect regions of the sky in Scorpio, Cygnus, Cepheus, Perseus and Monoceros. I believe it to be true that no other form of telescope but the old time portrait lens or similar combination is capable of dealing with these extraordinary objects.

It was not until the study of the peculiarities of comet tails with portrait lenses that we knew anything of the strange phenomena shown by them. It may be said that our knowledge of the extremely rapid transformations in the tails of comets dates from the photographs of Swift's comet of 1892, taken at the Lick Observatory with the lens previously mentioned and similar ones taken of the same object by Professor Pickering at Arequipa, Peru. Although the great comet of 1882 was successfully photographed, it showed no phenomena not known and already seen with the telescope. While only an insignificant affair visually, and but fairly visible to the naked eye, Swift's comet showed upon the photographic plates the most extraordinary and rapid transformations yet seen in any comet. One day its tail would be separated into at least a dozen individual streams and the next present only two broad streamers, which a day later had again separated into numerous strands, with a great mass, apparently a secondary comet, appearing some distance back of the head in the main tail, with a system of tails of its own. This remarkable appearance was the first known of its kind, though it was repeated in the photographs of Rordame's comet of 1893 taken by Professor Hussey. These peculiar phenomena seem to be a production of the comet itself—a result of the forces at work in the head of the comet.

The photographs of Brooks' comet of 1893, also secured with the Willard lens, showed such an extraordinary condition of change and distortion in the tail as to suggest some outside influence, such as the probable collision of the tail with some resisting medium, possibly a stream of meteors, such as we know exist in space. The long series of photographs obtained of this comet frequently showed great masses of cometary matter drifting away into space, probably to become meteor swarms. One of the pictures showed the tail of the comet streaming irregularly as if beating against a resisting medium and sharply bent at right angles near the end, as if at that point it encountered a stronger current of resistance. All of these wonderful phenomena would have been unknown to astronomers had it not been for these photographs, and the comet, instead of proving to be one of the most remarkable on record, would have passed without special notice. Though these phenomena were so conspicuously shown, scarcely any trace of the disturbance was visible with the telescope. On account of the apparent insignificance of the comet visually, no photographs were made of it elsewhere during its active period.

In the matter of discovery the photographic plate has accomplished a very great amount in certain directions. In spectroscopic work it has a field singularly suited to display its possibilities. In this direction it deals not alone with what can be seen, but it enters into the unseeable regions where the eye takes no cognizance of things. For though it is partly blind to the light which affects the eye, it can readily penetrate regions where we in turn are blind. And it is in this direction mainly where the photographic discoveries in spectrum analysis are immediately concerned, since it extends our vision into the invisible regions of the spectrum. The result must necessarily be one of discovery. It not only faithfully records spectral lines that cannot otherwise be seen, but by special treatment of the plate it also registers those visible to the eye and permits their accurate measurement.

From Doppler's principle it is known that the spectral lines have a normal position only while the object whose light is under examination is motionless in the line of sight. When it is in motion to or from us these lines are displaced from their normal position, in the first case towards the violet region of the spectrum, and in

the other towards the red. By comparing any of the lines in the spectrum of a heavenly body with the same lines in the spectrum of a stationary object it is possible to tell not only the direction of motion of the moving object, but to determine accurately the amount of this motion, for there is a known relation between the amount of displacement and the actual velocity, and this is independent of the distance.

This peculiarity, besides showing the motions of the individual stars, has revealed to us, through the aid of photography, an entirely new class of bodies, the so-called spectroscopic binaries.

The visual spectroscopic work, long ago, in the hands of Dr. Huggins, had shown the displacement of the spectral lines as the stars moved towards or from us. It remained, however, for photography further to extend this remarkable work by showing that not only were the lines displaced, but that in the case of certain of the stars the lines were periodically doubled at short intervals, thus indicating the presence of two bodies which must be rapidly revolving about each other. The doubling of the lines is due to the alternate approach of one and recession of the other body, which thus causes a displacement of the two sets of spectra, for when the motion is at right angles to the line of sight (and this must occur at two points in the orbit) the two spectra will be exactly superposed. It can readily be shown from the known periods of these stars and their enormous distances that no telescope is likely to be made so powerful as to show visually their independent components. The visual double star having the shortest period is one discovered by Burnham, and known as Kappa Pegasi, which he found to have a period of about eleven years. The spectroscopic binaries seem to revolve in extremely short periods—a few days—and in at least one case in a few hours, showing that they must be extremely close to each other. The explanation, to account for the observed peculiarities of their spectra, that these are actual double stars in rapid orbital motion must be accepted until some better explanation of the phenomenon be forthcoming, which does not at present seem likely to occur.

Among the first of these spectroscopic binaries discovered was Beta Aurigæ, which was detected at the Harvard College Observatory by Miss Maury, through the doubling of its spectral lines as shown on the various photographs obtained of it at that Observatory. This star has a period of four days, the relative motion of the components about each other being about 150 miles a second, and the distance between them about six millions of miles. In a similar manner, Dr. Vogel has found that the star Algol, so famous for its light variations, alternately approaches us and recedes, in a manner that can only be explained at present by the revolution of that star about some other body or about the center of gravity of the two. The spectrum of this star does not show any doubling of the lines, but a simple displacement from one side to the other of their normal position occurs consistent with the changes of the star's light. As there is no doubling of the lines, the conclusion is that there is but one spectrum. One of the stars is, therefore, a non-luminous body, and hence produces no spectrum. The old explanation of two hundred years ago, that the variation in the light of Algol is due to a dark body revolving about it and partially eclipsing it at intervals of a little less than three days, is hence proved by the spectroscope and photography to be the correct one. The frequent discovery of these spectroscopic binaries shows that they are by no means uncommon, and that possibly a considerable percentage of the stars consist of two or more bodies rapidly whirling about each other.

The beautiful phenomenon of the displacement of the spectral lines through motion in the line of sight has given rise to many important and interesting results, but certainly none more striking than that offered by Professor Keeler's spectroscopic proof of the meteoric constitution of the rings of Saturn. It was suggested soon after the discovery of the rings that they must be made up of discrete particles revolving in zones about the planet, which, from their smallness and great distance from us, gave the appearance of a system of solid rings encircling Saturn. This had been shown by Clerk Maxwell to be a mathematical necessity, and as the rings lay within Roche's limit, within which a large solid body would be broken up in revolving about a planet by the unequal attraction of the planet itself, it was certain that the rings must consist of small individual bodies. It remained for the spectroscope, through the aid of photography, to add its testimony to that of mathematical analysis. The problem offered to the spectroscope was simply to show whether the inner or the outer portion of the rings moved the faster. Should they revolve as a solid body the outer edge must necessarily have the greater velocity. But if they are made up of individual particles, then the attraction of the planet would cause those nearest to it to move the fastest, or, in other words, the inner part of the rings must have the greater velocity. This beautiful problem was successfully solved by the photographs of the spectrum of the rings obtained by Professor Keeler, where the displacement of the spectral lines by motion in the line of sight showed that the inner portion of the rings moved faster than the outer, and hence that the rings must consist of small bodies responding individually to the attraction of the planet.

The discovery of variable stars by photography can be compared with the wholesale business in commercial circles, because of the great number that are found on the various plates. These stars are not only found by the actual variation of their light, as shown by the size of their images on different plates, but many of them also show peculiarities in their spectra which at once stamp them as being members of a certain class of variable stars. So expert has Mrs. Fleming, of the Harvard College Observatory, become in detecting these bodies by their spectra that she instantly recognizes them at a glance among hundreds of other spectra on the same plate.

The most interesting and important of these Harvard College variable-star discoveries are found in the photographs of the globular clusters taken by Professor Bailey with the 13-inch telescope at Arequipa, Peru. It was found that a great many of the small stars that make up these clusters varied regularly and rapidly in their light, and in some cases a large percentage of the entire mass of stars was variable. So abundant are these variables, indeed, that as many as a hundred of them have been found in a space in the sky that would be covered by a pin's head held at the distance of distinct vision.

The clusters most prolific in variables are M 3, Omega Centauri, M 5, and a few others of this class. Perhaps the most remarkable circumstance, outside of the actual grouping of variables in such great numbers, is the fact that not a single variable star has been found in the great cluster of Hercules, the best known of these objects, and apparently like them in all other respects. Professor Pickering finds every star in this cluster constant in its light from the photographic evidence extending through ten years. * This would seem to mark this great cluster as being physically very different from the others referred to.

* Professor Bailey has since found that two of the stars of this cluster are slightly variable.

The writer has examined the cluster M 5 with the great telescope of the Yerkes Observatory and has visually verified a number of these variables. The brighter of them appear to vary slowly in their light, while many of the smaller ones are extremely rapid, passing through their entire light changes in a few hours. In the discovery of such objects, photography offers special advantages, since on the different photographs a thousand or more stars can be rapidly and accurately compared with each other and any variation in their light at once detected, while such comparisons in the actual sky, visually, would be limited to a very few stars. By the aid of the Harvard photographic plates over five hundred variable stars have been discovered in these clusters. It must be said, however, in speaking of the variables in the cluster M 5, that the two most prominent ones were really discovered visually nearly ten years ago by Mr. D. Packer with a very small telescope. These two seem to have been the first of the variable stars found in this cluster.

The shortest period variable so far discovered in the globular clusters—indeed, the shortest known variable—is a small star in the great southern cluster Omega Centauri, whose period is seven hours. These cluster variables seem to form a distinct class from the ordinary variable stars. It is very interesting to watch one of these small stars in a powerful telescope and to see with what quickness it passes through its light variation. One of the small stars in M 5, whose period is 12 h. 31 m., seems to be dormant for a large part of the time, as a very faint star, invisible in ordinary telescopes. It begins to brighten, and in two or three hours has risen nearly two magnitudes and faded again to its normal condition, while another and larger star quite near it seems to require a month or more to go through its light fluctuation.

Frequent reference has been made to the photographic work of the Harvard College Observatory. It is to be regretted that time does not permit a more detailed account of this work. No other observatory is so active in the application of photography to the various departments of astronomy. Not content with the available sky as seen from the northern hemisphere, Professor Pickering wisely established a branch observatory at Arequipa, in Peru, where a thorough photographic survey of the southern skies has been made, and a vast amount of work of high value has been accomplished, which has resulted in many important discoveries among the southern stars.

In dealing with the ordinary stars of the sky it has been shown that measures of the relative positions of the photographic images are strictly comparable with the best meridian circle work, while the number of stars that can be measured is vastly greater. The Pleiades, the cluster of Perseus, Præsepe in Cancer, etc., have all been measured with the micrometer, the heliometer and by photography. The comparisons have shown that photography has many advantages over the older methods, and the results are possibly even more accurate. These objects, however, are loose clusters, and the stars are not thickly crowded, and, moreover, the small scale of the photographic plate in such cases does not seriously interfere with the work. The great globular clusters of the sky, however, from the extraordinarily crowded condition of their stars, would almost forbid any attempt to deal with the individual positions by photography, except in outlying regions, where the stars are thinly scattered. No comparison between photographic and visual measures of such objects has yet been made, because no visual measures exist. The great cluster of Hercules is, perhaps, the easiest of these objects, both visually and photograph-

ically. It requires, however, a powerful telescope to measure the individual stars. Dr. Scheiner has given a catalogue of 833 of the stars of this cluster measured on photographs taken with the 13-inch refractor of the Potsdam Observatory. The stars that were measured all lie between the magnitudes 11.7 and 14. As a matter of comparison with visual measures, the writer has taken up the measurement of a few of the stars contained in Scheiner's catalogue. A rough inspection of the results so far obtained shows a close agreement between the visual and the photographic work. These observations also show that no appreciable change has taken place in the positions of any of the stars in the past six years, which, perhaps, is surprising, since one would expect a possible rapid change in some of the positions of the individual stars when they are massed so close together. They, however, seem to be as stable in their relative positions as are the stars elsewhere in the sky. A more remarkable object with a great telescope is the cluster Messier 5, in which the stars are more closely compressed and irresolvable than in the cluster of Hercules. This object has already been mentioned in speaking of the variable stars discovered at the Harvard College Observatory. The measurement of nearly 100 of these small stars has been undertaken with the great telescope of the Yerkes Observatory. Many of them are apparently in the very heart of the cluster, where the compression is the greatest. It is doubtful if at this time photographs can be made of this cluster upon which the crowded individual stars can be accurately measured.

It has been frequently photographed, but no measures have been made of the great mass of stars in the center of the cluster. It has been already stated that the accuracy of the photographic positions of individual stars is as great as the best meridian observations. The facility and ease with which the photographic positions are obtained is well shown in a report by Professor H. H. Turner, who is making the Oxford portion of the great Astrographic catalogue. An average of 3,951 measures per week is obtained. Over 150 stars per hour each can be measured by those most skilled in this work.

In the discovery of nebulæ, variable stars and asteroids, the photographic plate has done a great work which is still being carried on. The number of known asteroids has been doubled in the past few years (as many as nine have been found in a single night), and now it has become a matter of impossibility to keep track of them all, and they are found and turned adrift again unless they show some striking peculiarity of orbit.

Up to the present time but two comets have been discovered by photography. The first of these was discovered on a photographic plate taken by the writer on October 12, 1892, with the 6-inch Willard lens of the Lick Observatory, and was subsequently verified visually and observed at the different observatories. The second was photographed at the same Observatory by Mr. Coddington, with the same instrument, in July, 1898.

In photographing the sky it is found that the short focus portrait lens, from its small scale and large field, will show faint nebulosities beyond the reach of the larger photographic telescopes. This results from various causes. The action of these lenses upon the Milky Way, comet's tails and the great nebulosities of the sky does not seem to be strictly subject in practice to the law of the ratio of aperture to focus; or, if it is, this law must be somewhat modified in effect. The action seems to be quicker with the short focus lens than it should be. Probably, however, much of this is due to the small scale and the consequent compression of the image

into a smaller space, which would produce an intensification of its action. It is possible, also, that the photographic plate may be relatively more active with a bright image than with a faint one, which would give an advantage to the small relatively bright image of the portrait lens. This idea seems to be partly borne out by some experiments with a small lantern lens. This lens, $1\frac{1}{2}$ inches in diameter and about $5\frac{1}{2}$ inches focus, is much quicker than its light ratio would warrant, for it will photograph in a few minutes what the ordinary quick-acting portrait lens would require several hours to show. This was strikingly shown in photographs taken with it of the Milky Way. The scale of this lens is very small, and the cloud forms are so compressed that they act as a surface, and not as an aggregation of individual stars, as they must do in a larger telescope. If the focus is increased, the stars are scattered and the cloud no longer acts as a surface. With this small lens the earth-lit portion of the new moon was readily photographed in a single second, while with a 6-inch portrait lens of ratio $\frac{1}{5}$ from 20 to 30 seconds were required to show it well. The brighter cloud forms of the Milky Way were shown in from 10 to 15 minutes' time, while with the larger lens upward of three hours were required. Some of the diffused nebulosities of the Milky Way, notably in the region of Antares, are shown more quickly and more satisfactorily with this small lens, and a great wing-like nebula involving the star Nu Scorpio was discovered with it.

A list of discoveries made with these small lenses would be tedious; one of the most interesting, however, cannot be passed over because of its importance. There is no object in the entire heavens better known than the great nebula of Orion. With the lantern lens, a great curved stream of nebulosity was shown on the plates of this region covering a large portion of the constellation and some 17° long. It was found later that this had already been discovered by Professor Wm. H. Pickering with a $2\frac{1}{2}$-inch lens in 1889. This object seems to be an outlying appendage of the great nebula. The discovery very much extends our knowledge of the complicated and far-reaching influence of this mysterious object. In several other cases the photographic plate has shown us that the nebulæ are far vaster than we had ever conceived them to be, for their fainter extensions are not seen by the eye. What this knowledge may ultimately lead to in the reconstruction of our ideas of space and its contents can hardly be anticipated just now, though it must, necessarily, very greatly influence those ideas.

We have spoken of the Pleiades and the entangling nebulosities shown by photography to involve the stars of the cluster. The portrait lens has shown us that not only are the individual stars of this group involved in a nebulous system, but that streams and masses of this filmy matter stretch out for great distances all about the cluster.

The photographic plate has shown itself especially adapted, when used with the rapid portrait lens, for the accurate registering of the paths of meteors, and it promises to be of special value during the expected return of the November meteors this year, when a more exact determination of the radiant will be obtained from the photographs, and hence the orbit of the meteor stream will be better known.

In the reduction of the measures of the photographic plates for the great Cape Photographic Durchmusterung, Kapteyn discovered another 'runaway' star with a proper motion of 8.71 seconds a year, which is much greater than that of the celebrated 1830 Groombridge, and is at present the largest proper motion of any known star.

There are very few departments of as-

tronomy where photography has not taken a prominent, if not a commanding position. It is probable, however, that it will never take the place of the micrometer in the observation of close double stars, and in this direction the micrometer of Burnham will perhaps never be displaced. The photography of the surface features of the planets is in an almost hopeless condition at present, yet much can be expected in this direction when an increased sensitiveness of the plates has been secured.

Photography has shown its value in the determination of stellar parallax, and probably hereafter it will essentially take the place of the micrometer in this direction.

This is not the place to go into a discussion of the relative values of the refractor and reflector for photographic work. Where accurate measurement is to be considered, the refractor is doubtless better than the reflector. If, however, the main object is a great quantity of light, such as is required for the photography of the nebulæ, the large aperture of the reflecting telescope of short focus makes it, perhaps, the best form of instrument (though it is very much hampered by its small field). This has been shown to be true by Common and Roberts. Since in the reflector the light does not pass through the glass, it is possible to use very large apertures without any additional loss of light through absorption, as would necessarily occur if it passed through a large object glass.

Mr. Ritchey, of the Yerkes Observatory, is making a large glass speculum, five feet in diameter and twenty-five feet focus, which, when finished, will be one of the most powerful instruments for photographic and spectroscopic work yet made, and which deserves a more extended notice than my limited time will permit me to give it here. With this instrument, and Mr. Ritchey's skill in photographic work, results of high importance will be obtained.

Through the intelligent generosity of Miss Catherine W. Bruce, of New York City, astronomical photography has been placed on a firmer basis than it ever was before. Her gifts have been made to all departments of astronomy, and it would take considerable space to properly enumerate them all. Perhaps the most important of these are the ones that bear directly upon astronomical photography.

The first of these gifts was the great 24-inch photographic doublet by the late Alvan Clark, presented to the Harvard College Observatory, and which is now doing such excellent work in Peru; the two 15-inch portrait lenses for Dr. Max Wolf, of Germany, and a 10-inch photographic doublet for the Yerkes Observatory. These instruments are the most powerful of their kind, and for certain classes of work are superior to any other form of telescope. The results of the splendid gifts of this lady must hereafter have the greatest influence upon the higher development of astronomical photography.

It is impossible within the limits of this address to give more than a general, and at best incomplete, sketch of the rise and progress of photography in the various lines of astronomical research. To those who have kept pace with these rapid strides in the last twenty years this brief history will seem imperfect, and perhaps of little interest. Many applications of the photographic art and many valuable results have necessarily been omitted. But few of the names of those prominently identified with this subject have been mentioned, and but little of their work even alluded to. A volume of no small dimensions would be necessary to give a complete history of the development of photography in the many directions in which it has been applied to astronomy. The time to do this has not yet come. Progress has been so rapid and far-

reaching that its history, however complete and exhaustive, a year later requires to be re-written; and there is no reason for supposing that the end, or even the beginning of the end, has been reached. With new materials and new methods, and new workers who will profit by the experience and results gained by those who have in our time accomplished so much, we may expect for the new century far greater results than those briefly recorded here.

It would be difficult just here to predict the future of astronomical photography, though one can foresee something of the great results it must accomplish. It will displace some of the visual work, but it is more likely to move along new lines, opening up new fields of research. The older astronomy, so nobly represented by Simon Newcomb and a few others, will be strengthened at every point, and will stand all the more sublime for the help it shall receive from photography.

E. E. BARNARD.
YERKES OBSERVATORY.

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## *THE ZOOLOGICAL SECTION (F) OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.*

THIS section had a successful meeting. Papers of both a general and special nature were presented. The address of Vice-President Alpheus S. Packard, entitled 'A Half-Century of Evolution, with Special Reference to the Effects of Geological Changes on Animal Life,' has appeared in this JOURNAL. A brief outline of the papers read is presented in the following:

*Evolution and Migration of Hawaiian Land Shells.* By PROFESSOR ALPHEUS HYATT.

THE author studied about 22,000 shells, of which 18,000 at least were from Oahu. In that island there are about 280 species, as compared with about 140 in all the other islands of the group. There are three leading genera, Bulimella, Achatinella and Apex. The distribution of the species of these genera was represented on a large relief map of Oahu, by means of colored pins, connected by similarly colored threads. Each pin or series of pins represented a species, as indicated by attached labels.

All the shells probably sprang from a common ancestor, *Achatinella phœozona* G., which has become extinct in late years. Starting in the valley Kiliouou, as the shells migrated northward, there was an evolution of species and genera as plotted on the map. The principal occurrence of these mollusks is on the western flanks of the eastern range. The Bulimellæ inhabit the highest sides of the mountains, crossing to the eastern side, and there evolving a considerable number of species. This genus does not succeed in forming colonies in the range on the western crest of the island. The Achatinellæ occupy a lower zone below both the Bulimellæ and Apex. They cross to the eastern side of the mountains in several places; but are unable to contend successfully with the climate on that side. They were also unable to cross the valley lowlands in the center of the island, except in sporadic cases. The species of Apex occupy a middle zone, between the Bulimellæ and Achatinellæ, on the western flanks of the eastern range. They seem more delicate, and less able to contend with the surroundings on the ocean side of the hills. Not a species has been recorded from that side; but, on the other hand, it crossed the broad plain of the interior, and was successful on the short western range, where only a few sporadic species of the Achatinellæ are found. The evidence is that the species are distributed over the island in definite lines, which correspond to definite geographical areas. In the oldest part of the island are the oldest forms as evidenced by development.

*Variation in the Shell of Helix nemoralis, in the Lexington, Va., Colony.* By Professor James Lewis Howe.

Three series of this introduced snail were collected from gardens. There were over 1,000 shells in each lot. The colony originated in 1883. The conclusions reached from a study of these series are: (1) the variations tend in general along the same lines as in Europe; (2) the tendency of variations differs in different portions of the Lexington colony. The author gave a tabulated list of the varieties known in the Lexington colony, of which the total number was 385. Of these 277 were enumerated for the first time.

*Variation versus Heredity.* By Professor H. S. Williams.

Variation, and not heredity, is considered the fundamental characteristic of the phenomena of organisms. The arguments for variation versus heredity are as follows:

1. In any concrete case of natural selection, or other similar processes, the actual result of selection is the retarding and checking of variation, and the offspring necessarily evolves more slowly than its parent, in direct proportion to the efficacy of natural selection.

2. That the organic processes by which variation takes place in an organism differ from the ordinary process of development in individual growth only by passing beyond the limit reached by the ancestor, and hence variation is but a phase of the fundamental genetic process peculiar to living organisms.

3. That every act of variation is anterior to experience, and thus is necessarily original and genetic; whereas every hereditary act is necessarily secondary to and the result of experience, and the law of heredity must therefore be acquired in the process of evolution and is not fundamental.

4. That as to struggle for existence the most strenuous effort made (both by parent and offspring) in the course of organic processes is that which produces antagonism of interests. On the part of the parent it parts with that which has cost it the greatest expenditure of energy, and on the part of the offspring the result is the loss, in part or wholly, of the only source of its living up to the moment of the struggle.

5. That the orthodox view is inconsistent in so far as it recognizes mutability as applicable only to organic species and clings to the idea of the immutability of the more fundamental units of biology, viz., the individual and the cell and the protoplasmic states of matter.

These considerations bring us to a point of view in which heredity and variation hold a different relation to evolution than in the ordinary working hypothesis of biology. If this point of view presents the facts in their true relations we must seek for the immediate determining causes in variation, not in natural selection, nor in any of the environmental conditions, either direct or indirect, by which hereditary repetition is established, but in the phenomena of individual growth and development, and the more fundamental processes of cell growth and metabolism. (To be published in the *American Naturalist.*)

*Localized Stages in Growth.* By Dr. Robert Tracy Jackson.

As shown by Hyatt and others, stages in growth occur in the young and old organism, the adult representing full specific characters. The ontogeny of the individual therefore repeats, in an epitomized form, the phylogeny of the group.

From studies of animals and plants it has been found that stages may occur in localized parts throughout the life of the individual. In organisms that during growth present a serial repetition of similar parts there is often an ontogenesis of such parts, which is

more or less closely parallel to the ontogenesis of the organism as a whole, repeating characters seen in similar parts in the young individual and in adults of ancestral types. The repetition is usually of poembryonic or nepionic characters.

In asexual reproduction of Hydrozoa and Actinozoa, buds are given off, which during growth repeat characters seen in later stages of embryos from the egg. Young plates of the stem of certain crinoids throughout life repeat the features of the whole stem of ancestral forms. In ammonites that portion of the complex septum which lies close to the umbilicus is relatively simple, in this localized area repeating youthful and ancestral characters.

In plants, suckers from the roots, or base of stem, or stump, often repeat characters of the seedling, Pitch Pine, Areca, Oaks, Ash, Aralia, Sassafras, Ailanthus. In *Ampelopsis tricuspidata*, at the base, throughout life, the leaves are compound, as in seedlings. On all the remaining old wood, leaves are simple, trilobed (the species character); on wood of the current season's growth, leaves are simple, cordate, like a late stage in growths of seedlings. Degradational localized growth may be reversionary, as tuftlike growths of the Red Cedar, resembling the young and fossil allies. The terminal portion of leaves often repeats the character of leaves of seedlings in a close degree, seen in Tulip tree, Ashes, Ailanthus, Phœnix. Reversionary individual leaves often occur. These have failed to develop full specific characters and bear more or less resemblance to the young and fossil allies, seen in Tulip tree, Ashes, Negundo, Phœnix.

*On the Carboniferous Fauna of Rhode Island.* By PROFESSOR A. S. PACKARD.

THE fauna comprises worms, *Anthracomya arenacea*, crustacean trails, an Arachnid, and 14 species of insects, mostly cockroaches. Comparing with South Joggins, the animal remains support Lesquereux's reference of the beds (based on the flora) to the upper Carboniferous.

*On the Present State of our Knowledge of the North American Tertiary Mollusk Fauna.* By DR. WM. H. DALL.

REVIEWED fields covered by early workers from Say and Leseuer, in 1822, down to 1860, forming the first period, which was mostly on the coastal plain. A second group, Sowerby, Guppy, Gabb, were occupied with the Oligocene and Pliocene of the Antillean region.

A second period began about 1880. The new workers revised faunal lists, discriminated horizons, correlated continental and Antillean horizons,and discovered new horizons. The most important of these were the Pliocene of Florida, Miocene of Galveston, Texas, and Upper Oligocene of western Florida, as made known by Willcox, Heilprin, Dall, G. D. Harris, Aldrich and others. From recent discoveries, rich faunas have added a multitude of new forms.

*Leidy's Genus Ouramœba.* By WM. L. POTEAT.

HE showed that Leidy's view of the filaments as extensions of protoplasm was incorrect. They are mycelial filaments of a fungus, partially parasitic on an Amœba. The filaments arise from the germination of a spore, and issue at once into the water. The structure of the filaments is that of unseptate hyphæ, not of pseudopodia. The genus Ouramœba is not valid.

*Moniloporidæ, a New Family of Palæozoic Corals.* By A. W. GRABAU.

*Notes on Æolosoma tenerarum.* By MISS EDITH M. BRACE.

IT is shown that the nervous system of this worm, previously considered aberrant, conforms to the annelid type. The nervous system is connected throughout with the epidermis. The distribution of nerves and ganglia were described in detail. The sym-

pathetic system and sense organs were described; the latter consist of cells containing a pear-shaped refractive body, also compound bodies similar to the eyes found in other worms.

*A New Classification of Fossil Cephalopods.* By Professor Alpheus Hyatt.

Cephalopods with camerate shells, excluding Belemnoidea, are included in two orders, Nautiloidea and Ammonoidea. The classification of the Nautiloidea is in confusion, owing to the overthrow of the old systems. After revising all the genera and a considerable proportion of the species of this group it was found that the siphuncle offered the best basis for a classification. The siphuncle was of greater importance in ancient than in more recent times, in primitive than in specialized forms, and in the young than in later stages of ontogeny. This assumption is based on the relatively larger size, and more or less complicated structure of this organ, in ancient times, primitive types, and the young of all shells. Proposed sub-orders of Nautiloidea are as follows:

1. Holohoanites, funnels of siphuncle extending across air-chamber, deposits when present, more or less prolonged cones, filling endosiphuncle. Endoceras, Piloceras, Nanno.

2. Mixochoanites, siphuncles small, funnels composite, short in young, collars added in adult. Ascoceras, Aphragmites.

3. Schistochoanites, siphuncles large, funnels imperfect or split on outer side; these are at bases of flat rings or collars. Conoceras, Bronn (Bathmoceras, Barr).

4. Orthochoanites, siphuncles small, except in primitive forms, without deposits, or, if present, irregular and gathered around funnels, no endosiphuncle. Is difficult to separate some forms of this suborder from the Annulosiphonata. Orthoceras, Geisonoceras.

5. Cystochoanites, siphuncles of different sizes, funnels invariably short, bent outwardly. There are two subgroups. (A) Annulosiphonata, siphuncles large in primitive forms, beaded, internal deposits gathered about the funnels. There also are concentric layers advancing toward the interior, large endosiphuncle often present in primitive forms. Actinoceras, Loxoceras. (B) Actinosiphonata, internal deposits arranged as vertical radiating plates, directed toward interior, but not meeting; deposits increase in number of plates and thickness, so they often meet those of next segments. Jovellania, Rizoceras.

*On the Systematic Position of the Trilobites.* By Professor A. S. Packard.

Beecher has shown that all segments behind the antennal bear biramose limbs essentially alike for the head and trunk. In Crustacea, on the other hand, there is a differentiation of cephalic appendages. For this reason, with the different larval form, and obvious affinities of trilobites to Limulus which is not a Crustacean, we are inclined to refer trilobites to a separate class, older, more primitive, derived from the annelids on a different line from Crustacea. Probably the merostomes, including Limulus, descended from trilobites or similar forms.

*Measurements of two large Lobsters, recently added to the Collections of the American Museum of Natural History.* By Dr. E. O. Hovey.

Two large lobsters were caught off Atlantic Highlands, N. J., in 1897. Reported weight 31 and 34 pounds respectively. The length as mounted is respectively 92 cm. and 100.5 cm., or over 3 feet in each case.

*A New Method of Studying Underground Insects.* By Professor John B. Smith.

Shown that plaster of Paris, thinned, made excellent casts of burrows extending

nearly six feet underground, and branched. Satisfactory for burrows of bees, wasps, spiders, many coleopterous larvæ. The better the plaster the better the result. The best dental plaster mixed with an equal bulk of water is satisfactory.

*Notes on the Habits of some Burrowing Bees.* By PROFESSOR JOHN B. SMITH.

STUDIED by plaster method as referred to above. Several species were studied in Ocean Co., N. J.

*Colletes compacta* appears early in spring, digs almost vertically some 18 inches; then a horizontal burrow is sent off 2–5 inches. At the end a thin parchment-like cell is constructed, in which pollen and honey is stored, and the egg is attached about the middle of the cell. One or two additional lateral tunnels and cells may be built. The entire burrow is filled up, so that the young bees have to bore to the surface.

*Andrena bicolor* and *vicina* make burrows of greater diameter and sinuous, extending 40 inches or more below the surface. General habits of breeding as in Colletes. Some smaller species of Andrena line their cells with a sticky fluid; the pollen is formed in a loaf, on which the egg is laid.

*Augochlora humeralis* makes a vertical burrow nearly 6 feet deep. It sends off a short lateral burrow, then excavates a chamber 1-2½ inches across; 6–20 cells are constructed from this chamber and lined with clay. Pollen is placed in the form of a loaf, on which egg is laid. Two or three such clusters of cells may be made by one bee, and 30–40 cells may be found in a single cast. When starting the burrow the bee first makes an oblique burrow; after it begins to bore vertically it extends the upward burrow to the surface. The opening is concealed, and no earth is piled there. When the bee is in the burrow the entrance is closed by a ball of sand or clay. The bee does not fill the burrow, so that the young make an exit through the parent's burrow. They are also used as hybernating quarters. In early spring the females may be found piled on one another at the bottom of burrows.

*On the Markings of Nodontian Larvæ.* By PROFESSOR A. S. PACKARD.

As shown by Eimer and Cope, in the markings of lizards, changes from stripes to spots originate near the tail and extend forward in waves. Weismann has shown the same feature in caterpillars. The author observed the same in several Nodontian larvæ, *Lymmeristia albifrons*, *Dasylophia anguinea*, *Schizura concinna*. In these the longitudinal bands became broken up into spots on the last 4 or 3 segments, where banded arrangement disappears. The explanation is not obvious in lizards; in caterpillars it may be connected with the fact that new segments originate between the last body segment and the penultimate segment.

*The proposed Attempt to introduce Blastophaga psenes into California.* By DR. L. O. HOWARD.

CALIFORNIANS, in their attempt to produce a fig equal to the so-called Smyrna fig, have used cuttings imported from the eastern end of the Mediterranean. It was found that trees dropped the greater part of their fruit. It has long been known by Mediterranean growers that figs are fertilized by the insect *Blastophaga psenes*, which inhabits the wild Caprifig. Branches of Caprifig are collected annually and tied on to the branches of cultivated figs. The insects, loaded with pollen, enter the flowers of the cultivated figs and fertilize them.

In California artificial fertilization has been attempted and has been quite successful, the figs having the flavor of the Smyrna product. This has made it seem probable that if Blastophaga could be established in California a fig could be grown quite as

good as those imported. Caprifigs with their insects have been repeatedly imported, but attempts to establish the species have not been very successful. The author recently visited California and found Caprifigs abundant in numerous places. He thinks the time has come to carry on the experiment in a larger way and believes it will be successful.

*Notes on the Life History of Protoparce Carolina.* By Professor Wm. B. Alwood.

Breeding carried on with this species for two years shows that it is slightly double-brooded, at Blacksburg, Va. The earliest moths appear June 7th–12th. Oviposition begins June 20th; larvæ moult 4 times, at intervals of usually 4 days, become full fed in 20–21 days and enter the soil for pupation. A small part of early brood issues as adults the first year; but the greater part are single-brooded and appear as adults in July, after passing the winter as pupæ.

*The Life History of Schizoneura lanigera Hansen.* By Professor Wm. B. Alwood.

Breeding records show that the 'root and stem forms' can be colonized from root to stem, or the reverse, and their natural migrations were observed. Many of the agamic wingless females at Blacksburg, Va., survive the winter exposed on aërial situations. Records show twelve generations of agamic, viviparous females from May 12th to September 20th. At this date winged, agamic, viviparous females were produced in all the colonies observed. These proved a migrant generation and could not be induced to remain at rest on the apple plant under control conditions, but flew away. Under confinement they produced 4–6 young, which were sexed individuals. These are small, beakless, with rudimentary lobes where mouth parts should be; about $\frac{1}{3}$ are males and $\frac{2}{3}$ females. After copulation females lay one egg, which remains dormant over winter. From long observations it is concluded that in southern latitudes agamic individuals continue an unbroken chain, and that oviparous reproduction plays no important rôle in the life cycle. Only a small per cent. become winged, but on the contrary continue as normal, agamic, wingless lice.

*The Phylogeny of North American Eucleidæ.* By Dr. Harrison G. Dyar.

The Eucleidæ is a family of moths represented by 28–31 species in this country. The author is acquainted with life history of 20 species, and a partial life history of one other has been published. Larvæ offer structural characters of value in classification, and he presented a phylogenetic chart of the 21 species where the young is known. In the first division the lateral tubercle of the first abdominal segment is lost. One branch shows the origin of stinging spines. In another branch the first division corresponds to the loss of the primitive first stage, on the one hand, and to the complete suppression of the many paired warts, on the other. (To be published in *Journal N. Y. Entomological Society.*)

*On the Genitalia in Ants, and their Value in Classification.* By W. H. Ashmead.

*The Records for 1898 of Broods VII. and XVII. of Cicada septendecim.* By C. L. Marlatt.

*Remarks on Aphorphora.* By Professor Edward S. Morse.

*Fossil Butterfly from the Base of the Severn Formation* (Cretaceous) *of The Potomac River Exposure.* By P. R. Uhler.

*On the Types of Vertebrate Embryos.* By Professor Charles Sedgwick Minot.

*On the Embryology of the Rabbit.* By Professor Charles Sedgwick Minot.

*Some New Points in Dinichthyid Osteology.* By Dr. C. R. Eastman.

*Dinichthys pustulosus*, as shown by many characters of the cranial and dorsal shields,

is the most primitive known species of the genus.

In the cranial osteology of *Dininchthys intermedius* the 'parietal' and 'frontal' elements of Newberry and other authors, declared not to exist, the area assigned to them being covered by the centrals, as in *D. pustulosus*, and uniformly throughout the family. Identification of the side plates of the body, heretofore considered missing. The upper or transverse arm of the 'clavicular' is homologous with the anterior lateral of Coccosteus, and the inner branch of the bifurcated arm with the interlateral of the same genus. Outer branch of the bifurcated arm has articulated to its distal end a warped plate, supposed to represent a modified branchiostegal apparatus. The term 'clavicular' is thus a misnomer, since the element has nothing to do with a shoulder-girdle, and there is no evidence that such a structure was present in the Dinichthyids.

The orientation of the clavicular was described and illustrated by diagrams. The osteology of *Titanichthys agassiszii* was also described and illustrated by diagrams.

*Transformation of the Brook Lamprey (Lampetra wilderi), and Parasitism among Lampreys.* By PROFESSOR SIMON HENRY GAGE.

THE transformation of all lampreys is similar, as far as known. The egg develops into a larva comparable to a tadpole, and this transforms into an adult. Up to the present the larvæ of the sea, lake and brook lampreys have not been distinguished. At transformation the sea and lake lampreys are about 150 mm. long, while adults average 700 and 350 mm. respectively. The transformation of the lake lamprey requires 20–30 days until adult form is assumed, but metamorphosis is only begun in this time, and the animal stays under the sand, like a larva, for about 4 months before emerging for a free predatory life.

The brook lamprey attains full size during larval life, and remains under sand some 7 months; it then emerges, builds nest, lays eggs and dies. In the lake lamprey (*Petromyzon marinus unicolor*), from Cayuga Lake, no food, except blood, has been found in the enteron. As the brook lamprey has the same armature of teeth and rasping tongue as lake and sea lampreys it has been considered as also parasitic, but this is a mistake, as shown by experiments in aquaria. The suctorial mouth is used in all lampreys for nest building and mating; the question arises: was the buccal armature developed for this purpose or for a parasitic life?

*Hybernation, Transformation and Growth of the Common Toad (Bufo lentiginosus americanus).* By PROFESSOR SIMON HENRY GAGE.

IN literature it is stated that the toad hybernates under leaves, logs, etc. From observation it is believed hybernation occurs only in the ground, rather dry and not liable to be frozen. After emerging in spring, if a cold snap occurs, they seek shelter of leaves, etc. In burying itself the toad backs in, the hind legs and caudal end of body being used for digging, and forelegs for pushing backward. No sign of the hole is left.

In a freezing atmosphere the temperature of the toad was $\frac{3}{4}$ to $1\frac{1}{4}$ degrees Centigrade higher than surrounding medium. Toads found under frozen leaves were able to crawl. In one case the legs and skin were frozen solid, but not the internal organs; the toad recovered. When frozen solid the toad never recovered.

At Ithaca ovulating extends from the middle of April to the middle of June. Eggs are normally laid in a double string, one from each oviduct; 500–5,000 or more are laid at one time. Eggs hatch in about 4 days. Growth of tadpole is attained in about 40–60 days. After hind legs are well developed

no food is taken and a tadpole changes into a toad within 3 days. We get a clue to activity of life processes in transformation by weighing. A tadpole at maximum size weighed 230 milligrams; after hind legs developed and food was no longer taken, weighed 110 milligrams; two days later, when tail is only 3 mm. long and the little toad has crawled out into air, weight was 70 milligrams; less than $\frac{1}{3}$ the weight of tadpole from which it developed.

In man and other animals the proportion of water is greater the younger the animal. In a tadpole 91.6% of live weight is due to water; in the just transformed toad 88% is water. The dry weight of a tadpole was 19 milligrams; of a transformed toad, 8 milligrams, less than half the dry weight of the tadpole. There is, therefore, a great loss of substance other than water in transformation of tadpoles into toads. In the growth of the toad there is a steady increase from egg to maximum of tadpole. During transformation there is shrinkage. When the little toad is ready to take food its progress in size is rapid, and in a few years it may be 50,000 times as heavy as the egg from which it came.

*On the Piscine Ancestors of the Amphibians.* By Professor Theo. Gill.

*A Historical Notice on Ross' Rosy Gull, Rhodostethia rosea.* By John Murdoch.

This species was discovered by Sir James Ross, in 1823, at Alagnak, Melville Peninsula. It was described by Richardson in 1825. Up to 1881 only 14 specimens were known, but from several localities. The Point Barrow expedition (1881–93) found them in large numbers, flying northeast along the shore each autumn, and collected a good series. The delicate pink of the breast after death soon fades on exposure to light. Fifteen additional specimens have since been taken, all from the Arctic region except one (Bering Id.). Nansen found them abundant in July, near Hvitdenland (81° 38′ N.). They undoubtedly breed there, but the main breeding ground is probably the land believed to be not far north of Point Barrow. They probably always keep close to the loose edge of the ice-pack. (To be published in full in the *Auk*.)

*The Winter Food of the Chickadee.* By Clarence M. Weed.

The paper records a study of the food of the Black-capped Titmouse (*Parus atricapillus*) during winter months. Forty-one specimens were studied from November, 1897, to March, 1898. Results show that this bird feeds on a large variety of insects. The most striking item of food was eggs of aphids, 21 per cent. of the whole. Insects as a class constituted 51 per cent., spiders and their eggs 5 per cent., vegetable matter 28 per cent.; of this 20 per cent. consisted of buds and bud scales, introduced accidentally with aphid eggs; indeterminable 10 per cent.; grit and other extraneous matter 4 per cent. This study yields additional evidence of the usefulness of this familiar bird.

*A Rare Species of Whale.* By Professor Alpheus Hyatt.

The specimen came ashore on the beach at Annisquam, Mass., August, 1898. The specimen proves to be a species of Mesoplodon, is 12 feet long, measuring along the body. Two teeth, characteristic of the genus, exist in the mid-length of the lower jaw, but are small and not visible above the gum. The only species known in the North Atlantic is *Mesoplodon bidens*; this specimen is probably of that species. This species has been recorded from European coasts, but has been a very rare visitant of our shores.

*Variations in Human Bones.* By Dr. Thomas Dwight.

A lecture delivered before the Zoolog-

ical (F) and Anthropological (H) Sections. The speaker dwelt especially on anomalous spines of the vertebral column.

*The Fauna of Cold Spring Harbor.* By DR. C. B. DAVENPORT.

GAVE a general account of this station, a description of which will be published later in this JOURNAL.

*Naples Station: General Description and Notes on Methods of Work Employed There.* By DR. E. O. HOVEY.

THIS laboratory was established in 1872, by Dr. Anton Dohrn. Although some thirty stations have since been established on similar lines, this has maintained its lead in importance. The most popular feature is the aquarium, which consists of 26 tanks (described in some detail). The chief function is investigation, which is carried on by a corps of nine regular officials, and 30–40 students from all parts of the world. More than 1,000 men have studied at the Laboratory. An important feature is the beautiful preparations of the Naples marine fauna, which are sent to museums and investigators all over the world. The paper presented many interesting and practical details of methods employed.

*General Statement of Types and Figured Specimens of Fossil Invertebrates in the American Museum of Natural History.* By DR. E. O. HOVEY.

THE Museum has at least 8,000 types and figured specimens of fossils. A large part of these are in the James Hall collection, including a large proportion of species of the New York Palæozoic horizons; also important series from Waldron and Spergen Hill, Indiana; Racine, Beloit and other localities in Wisconsin and Minnesota. The Museum has the F. S. Holmes collection, including many Tertiary and Post-Tertiary types from South Carolina; the types of Hall and Meeky from the Cretaceous of Nebraska and many types of species described in the Bulletin of the Museum. In the paper a number of other lots of types and figured specimens are mentioned which cannot be referred to in this brief abstract.

*Ink and Paper for Museum Labels.* By DR. ROBERT T. JACKSON.

DWELT on the importance of carbon writing and rubber stamp inks, as being the only inks suitable for permanent records. Bond or linen record paper advised as being lasting. Ordinary paper not suitable for permanent records. This paper will be published in this JOURNAL.

ROBERT TRACY JACKSON,
*Secretary of Section F.*

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## NOTES ON PHYSICS.

### SECTION B AT THE BOSTON MEETING.

THE program of Section B contained fifty titles of papers, forty of which were read in full. Many of these papers were of high order and almost every one was creditable and interesting. The increasing activity of Section B and its growing membership are matters for congratulation, and it is probable that an affiliated American Physical Society may soon become desirable and feasible. The proceedings of Section B will be reported in SCIENCE at an early date.

### THE FLOW OF WATER IN PIPES.

THE flow of water in pipes and channels is again the subject of elaborate investigation,* but it is doubtful whether anything more than roughly approximate formulation of the laws of flow of water can ever be reached. It seems that the slightest roughness on the inside of a pipe leads to *unstable states* of fluid motion resulting in the formation of eddies. If incipient eddy motion is indeed an unstable state of fluid motion—and our knowledge of vortex sheets, such, for example, as the air jet of an organ pipe, seems to show that it is—then the flow of

* Paper by G. H. Knibbs, Journal and Proceedings of the Royal Society of New South Wales (XXXI.).

water in anything but a mathematically smooth pipe *cannot be rigorously treated by any of the methods of rational mechanics*, for the very troublesome characteristic of all unstable states of a system is that subsequent aspects of the system are *influenced to a finite extent by infinitesimal initial causes*. The flow of water in a pipe is, in its details, about as difficult to rationalize as the weather.

### THE SYNCHRONOGRAPH.

Professor A. C. Crehore and Lieutenant G. O. Squier have devised means for using individual pulsations of a sinusoidal alternating current for signalling in high-speed telegraphy. Their Synchronograph, as the instrument is called, has been tried by the inventors on some of the lines of the British Post Office, and the results show that the Synchronograph is capable of transmitting words from three to seven times as fast as the Wheatstone apparatus at present in use.

### SCIENCE ABSTRACTS.

A new periodical of the above title is now being published under the direction of the Physical Society of London and of the British Institution of Electrical Engineers. This journal aims to give a complete abstract of current literature in physics and electrical engineering. It certainly has good reason to be, and it will no doubt prove to be of great usefulness to English-speaking physicists and engineers. The abstracting of (foreign) physical papers in the Proceedings of the Physical Society is discontinued.

### CATHODE RAYS.

Sir Wm. Crookes' original hypothesis that cathode rays consist of rapidly-moving, negatively-charged particles is proving to be increasingly useful in leading to and interpreting new experiments. Lenard* has recently measured the variations of velocity of cathode rays, which are produced when the rays pass parallel to the lines of force in an electrostatic field—a field independent from that which produces the rays. These measurements were made by observing the deflection of the rays by a magnetic field. The velocity of the cathode rays, calculated from the observed deflection, ranges from $\frac{1}{10}$ to $\frac{1}{3}$ of the velocity of light. These variations of velocity were also clearly indicated by observed variations of the deflection produced when the altered cathode rays were passed at right angles to an auxiliary electrical field, though the author did not calculate the various velocities in this case from the observed electrostatic deflections.

Merritt* has shown that cathode rays reflected from a platinum obstacle have the same velocity as the incident rays—that is, to say the reflected and incident rays are equally deflected by a magnetic field. If the moving particles in the cathode rays are about $\frac{1}{1000}$ as massive as hydrogen molecules, as has been pointed out by J. J. Thomson, then these particles should show but little diminution of velocity after impact with platinum molecules, and corresponding to this the reflected and incident rays should be equally deflected by a magnetic field.

### THE ELECTROCHEMICAL EQUIVALENT OF SILVER *vs.* THE MECHANICAL EQUIVALENT OF HEAT.

Rowland's value of the mechanical equivalent of heat, reduced by W. S. Day† to the Paris hydrogen temperature scale, is distinctly different from the value of this equivalent as determined electrically by Griffiths and by Schuster and Gannon. The electrical method involves the electrochemical equivalent of silver, inasmuch as the measurement of current was carried out in these experiments by means of the silver voltameter. A redetermination of the

* Wied. Ann., Vol. 65, p. 504.

* Paper read before Section B at Boston.

†*Physical Review*, VII., 193.

electrochemical equivalent of silver by Patterson and Guthe,* under a grant from the American Association, brings Griffiths' value for the mechanical equivalent of heat into coincidence with Rowland's value. This work of Patterson and Guthe is of the greatest importance and is greatly to the credit of the American Association Committee on Standards of Measurement.

W. S. F.

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## *CURRENT NOTES ON METEOROLOGY.*

### PAPAGUERIA.

SINGULARLY emphatic is the control exercised by the climatic conditions in the arid region of southern Arizona over the animal and vegetable life that is found there, as is shown by McGee in a recent article on 'Papagueria' (*National Geographic Magazine*, August). The district inhabited by the Papago Indians, south of the Gila river and southwest of the Sierra Madre and bounded on the southwest by the Gulf of California, is extremely arid. The scanty vegetation is fitted for its peculiarly difficult struggle for existence by being pulpy in structure and having impervious rinds for preserving moisture, as well as by being provided with thorns. The animals are armed with mandibles, stings, poison glands and other protective devices. In order to carry on the struggle for existence as successfully as possible, animal and vegetable life associates itself in communities, where grasses, trees, cacti, insects, reptiles, birds and mammals live together in harmony and mutual coöperation. The most interesting control of the climate is naturally that over man. The keynote to the understanding of the life and habits of the Papago Indians is to be found in the climatic conditions. The semi-nomadic life of the greater portion of the tribe; the building of their rude huts in the vicinity of permanent or temporary springs; the absolute dependence of the times of planting and of harvesting upon the storms or freshets; the migrations southward and northward with the coming on of summer or winter—in these and in many other ways climate is seen to be the great control in the life of the people. As the writer strongly emphasizes at the conclusion of his extremely interesting paper, "the life of the Papago is a round of migrations and wanderings, largely in search of the means of subsistence, of which the first and the second and the third are water, *water*, WATER—water to alleviate his own thirst in the sun-parched deserts, water to sustain his horses and burros and kine, water to vivify the plants of which man and his creatures eat."

*Reported to Section B at the Boston Meeting.

### TREE PLANTING ON THE PLAINS.

A NUMBER of points of meteorological interest are found in Bulletin No. 18 of the Division of Forestry, entitled 'Experimental Tree Planting in the Plains,' by Charles A. Keffer, Assistant Chief of the Division. The experimental tree plantings described in this report were begun in 1896, in South Dakota, Nebraska, Kansas, Colorado, Minnesota and Utah. Protection, then amelioration of climate, is the principal object of the plantings, a wood supply being a secondary consideration, for the growing of timber on a commercial scale on the Plains is hardly to be expected. That a lack of sufficient moisture is the cause of the treelessness of the Plains has often been claimed, but many artificial plantings are now growing successfully in what was a few years ago a treeless region. A study of the climatic and soil conditions, and the results of the experiments, lead to the conclusion that the line of successful tree culture will move westward as the agricultural development of the country goes on, and as the soil is more and more broken up and disintegrated. The preva-

lence of winds in the region of the Plains is hostile to agriculture, by reason of the increased transpiration from vegetation and the evaporation from the soil thereby produced; and trees planted in masses or large groves, in selected locations, form excellent wind-breaks and protect the crops for some distance to leeward of them. The Bulletin contains full descriptions of the various experimental plantings and is well illustrated.

R. DeC. Ward.

Harvard University.

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*BACTERIOLOGICAL NOTES.*

The bearing of optical aids upon the growth of our knowledge of disease-producing germs is well illustrated by two contributions recently made to the Ninth International Congress of Hygiene and Demography, held at Madrid. The work of Loeffler and Frosch on the ætiology of foot and mouth disease in cattle was reported. The disease-germ of this disease is so small that it passes, contained within the lymph, through Berkefeld filters that hold back the smallest known microorganisms. This germ is thus far known by its effects only, for the highest power of the microscope fails to disclose anything in the filtered lymph, which is yet capable of setting up the disease upon inoculation. That the disease does not depend upon some soluble toxic agent contained within the lymph is proved by the fact that the disease has been transmitted through a series of six animals, the original material, which was employed for the first inoculation, having been obtained from a case of the natural disease. In each successive inoculation the lymph was filtered. We know of no toxic substance so potent, nor, indeed, is it probable that anything but a living and multiplying organism could be so active as to be transmissible through such a number of cattle, each one of which succumbs in turn to the disease produced. These authors do not even conjecture as to the probable character of the microorganism concerned.

The microorganism of infectious pleuro-pneumonia of cattle has also been sought by many bacteriologists. It has just been obtained by Nocard and Roux. The lymph taken from the affected lungs is highly infectious and readily produces the disease in cattle upon inoculation. Cultures made with this material had always remained sterile, and most painstaking search had failed to reveal any foreign elements in the lymph. By a novel procedure, first introduced by Metschnikoff, Nocard and Roux succeeded in obtaining cultures of the microorganism. If small sacs (or bladders) made of celloidin are filled with sterile bouillon and placed in the peritoneal cavity of the rabbit they undergo no change, the fluid remains clear and limpid, and the animal is unaffected. If, however, a minute quantity of the lymph from an infected lung is introduced into the sac, after a period the bouillon becomes opalescent. Transplantation from one sac to another brings about similar results. Microscopical examination of the turbid fluid shows an entire absence of wandering or other body cells, but a magnification of 1,600 to 1,800 times brings to light very minute round or elongated bodies which are believed to be the parasites of the disease. After the sacs have remained for a time in the abdominal cavity of the rabbit these animals lose weight and become cachetic. Albumen probably diffuses into the sacs and toxic substances into the peritoneal cavity. These cultures are exceedingly active and produce the typical disease upon inoculation. At first all attempts to cultivate this minute organism outside the body failed, but later through the use of a special culture medium success was achieved.

It is safe to assume that the parasite of foot and mouth disease is much smaller

than that of pleuro-pneumonia, as the latter does not pass through filters designed to exclude ordinary bacteria. And it is also highly probable that a further refinement of the microscope will bring to light not only the organism of foot and mouth disease, but probably many more infinitesimally small living forms.

SIMON FLEXNER.

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## *CURRENT NOTES ON ANTHROPOLOGY.*

### THE FOLK-SONG SOCIETY.

As a branch of the study of folk-lore, what may be called folk-songs, *Volkspoesie*, has long held a prominent place. Ten years ago Dr. Krejci wrote: "Die Volkspoesie ist der eigenste Ausdruck der Volksindividualität." The time was quite ripe, therefore, when this summer in London the first meeting was held of the 'Folk Song Society,' under the presidency of Lord Herschell. Its aim is to discover, collect and publish folk-songs, ballads and tunes. Meetings will be held from time to time and collections will be published.

The subscription is 10s. 6d. annually, and those who wish to become members should address the Honorary Secretary, Mrs. Lee, 41 Rosary Gardens, London, S. W.

### ARTICLES ON WAMPUM.

IN the *American Antiquarian* for February there is an article by the Rev. W. M. Beauchamp on 'Wampum Used in Council and as Currency.' He collects a number of examples of both uses from early writers, but acknowledges that "very few shell beads of any kind are met with on the earlier sites of the Huron-Iroquois."

This fact accentuates a historic doubt I have expressed in the *Bulletin* of the Museum of the University of Pennsylvania (May, 1898) that wampum belts were made by the pre-historic Indians. All known to me are later than the discovery and none have been found in ancient burials. Even the form of bead seen on the belts does not occur in pre-Columbian interments (Holmes).

### NATIVE FACE-PAINTING.

PAINTING the face is probably the oldest of the fine arts, at least the learned Dr. Hoernes says so in his last book. That it is not yet extinct we all know. How it is carried on among the Indians of British Columbia is the subject of a handsome monograph written by Dr. Franz Boas and published by the American Museum of Natural History, June, 1898. He explains the complex designs adopted and the symbolism they convey, and adds nearly a hundred illustrations drawn from life. The general artistic principle of the native artist is to force the form into the decorative field in such a way as to bring into view its important parts, at no matter what sacrifice of perspective and natural relations. Conventionalism is carried to the extreme, and it often exercises the ingenuity of the observer to make out what subject is represented.

D. G. BRINTON.

UNIVERSITY OF PENNSYLVANIA.

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## *SCIENTIFIC NOTES AND NEWS.*

THERE were about 200 members in attendance at the Fourth International Congress of Physiologists, which met at Cambridge from the 23d to 26th of August. A number of important papers were contributed, of which we may be able to give some account in a future issue. The Fifth Congress will be held by invitation of Professor Mosso at the University of Turin in the latter part of September, 1901.

AT the closing meeting of the International Congress of Zoology a committee was appointed, consisting of Professor Schulze, Professor Pelseneer, Mr. A. H. Evans and Professor Mark, to report on the practicability of uniformity in abbreviations and other questions of terminology.

AN international congress on maritime fisheries was opened at Dieppe on September 2d.

There were 300 members present, Great Britain, France, the United States, Russia, Italy, Norway, Denmark, Spain, Belgium, Japan and Venezuela being represented.

Dr. Hubert Ludwig, professor of zoology at Bonn, and Dr. G. Haberlandt, professor of botany in the University of Graz, have been elected corresponding members of the Berlin Academy of Sciences.

Professor Volkens has been appointed one of the custodians of the Botanical Gardens at Berlin.

Professor Koch, who, as we have already reported, is now in Italy studying malaria, has been given a dinner by men of science at Rome, presided over by Professor Baccelli.

Dr. D. Morris, lately Assistant Director of the Royal Gardens at Kew, takes up, from the 1st inst., the position of Commissioner of Agriculture for the West Indies, to which he was appointed some time ago. He will preside over the new botanical department which has been constituted as a charge on the Imperial fund in accordance with the recommendation of the West Indian Royal Commission and the recent vote of the House of Commons. He left for Barbados on the 21st inst.

Sir William Martin Conway has made the ascent of Mount Illimani, one of the loftiest peaks of the Bolivian Andes, about twenty-five miles east of La Paz. The mountain is 22,506 feet high, and the ascent occupied five days.

Mr. C. F. Baker, Assistant Zoologist in the Alabama Agricultural Experiment Station, has been given leave of absence for eighteen months, beginning January 1, 1899, to visit South America on a collecting expedition.

Dr. Robert Zimmermann, formerly professor of philosophy at Vienna, died on September 1st at Salzburg, in his 74th year. He had made important contributions to æsthetics and other departments of philosophy, being regarded as one of the leaders of the Herbartian school.

Dr. Dietrich Nasse, associate professor of surgery at Berlin, was killed by an Alpine accident in the Upper Engadine at about the 1st of September. Only two weeks ago we were compelled to record the death of Professor Hopkinson by a similar accident. Remembering the deaths of Francis Balfour, of Milnes Marshall and of other scientific men we have a heavy account against the Alps.

At the recent Syracuse meeting of the American Microscopical Society officers were elected as follows: President, Dr. William C. Krauss, of Buffalo; First Vice-President, Professor A. M. Bleile, of Columbus, O.; Second Vice-President, Dr. G. C. Huber, of Ann Arbor, Mich.; Secretary, Professor Henry D. Ward, of Lincoln, Neb.; Treasurer, Magnus Pflaum, of Pittsburg; Executive Committee, Professor S. H. Gage, of Ithaca; Dr. A. Clifford Mercer, of Syracuse, and Dr. V. A. Moore, of Ithaca.

Dr. W. H. Wiley, Secretary of the Association of Official Agricultural Chemists, has sent out a notice stating that, in harmony with the vote of the Executive Committee, the date of the fifteenth annual meeting of the Association has been fixed for November 11th. The sessions will be held in the lecture hall of the Columbian University, Washington, beginning at 10 a. m., Friday, November 11th, and continuing Saturday and Monday, or until the business of the Association is completed. These dates immediately precede the meetings of the Association of Agricultural Colleges and Experiment Stations, which will convene in Washington, November 15th. The order of business agreed upon by the Executive Committee is as follows: Report on nitrogen; on potash; on phosphoric acid; on soils and ash; on foods and feed stuffs; on food adulteration; on dairy products; on sugars; on tannin; reports of special committees.

The geographical societies of twenty-five towns of France and French Africa are sending delegates to the nineteenth session of the National Congress of French Geographical Societies, which meets at Marseilles from the 19th to the 25th of September. Prince d'Allenberg is President of the Congress.

Arrangements have been made by the authorities of Georgetown University, Washington, D. C., for a course of six illustrated popular lectures, open both to students and to citizens of Washington. The subjects are as follows:

October 12. Household Insects, L. O. Howard, Ph.D.

October 10. Marine Life, James E. Benedict, Ph.D.

October 26. Biology of the College Walks, Sylvester D. Judd, Ph.D.

November 2. Jack Rabbit. T. S. Palmer, M.D.

November 9. German-American Pork Question. Ch. Wardell Stiles, Ph.D.

November 16. Geographical Distribution of Animals and Plants, C. Hart Merriam, M.D.

THE seriousness of the recrudescence of the plague seems to be scarcely appreciated, if we may judge from the comparative silence of the daily papers. Since August 6th the number of cases in Bombay and throughout the Presidency has greatly increased, no fewer than 2,300 deaths having occurred in the Presidency during the last week regarding which news is at hand. Plague is also epidemic in the Madras Presidency and occasional cases occur in Calcutta.

MOUNT VESUVIUS is in eruption more actively than at any time since 1872. The central crater and some seven new outlets are throwing out lava and ashes. Imposing streams are flowing down the mountain sides, burning the chestnut woods at the base of Monte Somna, nearly reaching the Observatory, and destroying part of the railroad. Professor Tasconi, the Director of the Observatory, does not expect, however, that any serious damage will be done.

THE daily papers have published full details of the destructive hurricane which on the night of September 11th swept over the Windward Islands and proved especially destructive at St. Vincent and Barbados. The Weather Bureau furnishes the following statement: "The hurricane which created such destruction in the West Indies on Sunday night was detected at its inception on Saturday by the new West Indian hurricane service of the Weather Bureau of the Department of Agriculture. At 8 a. m. on Saturday morning observations on the islands of Martinique and Trinidad gave slight indications of a disturbance southeast of the Windward Islands. At 12:40 p. m. a special observation at Barbados indicated a fall of nearly $\frac{1}{10}$ in the barometer during the preceding two hours. This movement of the barometer at Barbados, taken in connection with the whole atmospheric survey made four hours previously, satisfied the forecast officer that the hurricane would soon develop over the Windward Islands, although to the non-expert there were no indications of a coming storm. Hurricane warnings were immediately despatched to all ports in the islands of Barbados, Martinique, St. Kitts and St. Thomas, and they were advised to prepare for a destructive storm. Cable communication was perfect and the warnings were promptly received. They were informed that the hurricane would move from a point south of Barbados, and that it would travel slowly northwesterly, with wind increasing to a hurricane velocity. Advisory messages were sent to Colon, Curaçoa, San Domingo, Trinidad and Santiago. A message was also sent to Admiral Watson's fleet, lying in the harbor of Caimanera, Cuba. How completely these warnings were verified by the coming of the storm twenty-four hours later is shown by the press despatches of this morning. While the destruction of life and property has been great, there is no question but that hundreds, if not thousands, of lives and millions of property were protected by the complete warnings given by the United States. These warnings were of profit to the commerce of all nations. Without considering the saving in human life, they have, from a commercial standpoint, fully justified the President in asking for the necessary appropriation, and in personally conducting the inauguration of a complete and efficient meteorological service."

THE *Electric World* quotes from the London *Electrician* an application of wireless telegraphy at a recent regatta, when Signor Marconi demonstrated the adaptability of his system to the transmission of press intelligence from a steam launch in motion. The yachting expert on deck dictated his account of the races while these were in progress, and a stream of dictated 'copy' descended below deck to Signor Marconi, who sat in a cabin working his transmitter, whence the ether waves carried the news with a mimimum loss of time to a fixed receiving station on shore. Arrived at this point, the news was forwarded to the press offices by telephone. It is stated that one edition

of the local *Evening Mail* contained two whole columns of news dispatched entirely by wireless telegraphy. The notable event is undoubtedly the germ of an important development of wireless telegraphy in the near future.

The Duke of Abruzzi is about to issue a book describing his recent ascent of Mount St. Elias. The author's and illustrators' profit upon it are to be devoted to a fund for assisting needy Italian guides.

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*UNIVERSITY AND EDUCATIONAL NEWS.*

It was announced last spring that $500,000 had been given to the Medical College formed by the professors resigning from the Medical School of New York University and annexed to Cornell University. The gift was at the time made anonymously, but was supposed to be from Colonel Oliver H. Payne, one of those who resigned from the Council of the University after the difficulties. It is now definitely announced that Colonel Payne is the donor and that the gift to the Cornell University Medical College amounts to $1,500,000. Plans for a building to cost $500,000 are being made by McKim, Mead & White, the architects, and work on the structure is to be begun within thirty dys. The plot of land which has been purchased is the entire block on the west side of First Avenue, between Twenty-seventh and Twenty-eighth Streets. It is expected that the new building will be ready for occupancy by October, 1899.

The late Rowland Hazard, of Peacedale, R. I., has bequeathed $100,000 to Brown University. This sum is not to be paid for three years, and if the estate should depreciate in value the executors are empowered to reduce the amount to not less than $50,000.

Mr. George A. Gardner has given $20,000 to the Massachusetts Institute of Technology, to be added to the general endowment fund.

Dr. D. K. Pearsons, of Chicago, has offered $50,000 to Fairmount College, Wichita, Kans., on condition that $150,000 can be raised.

Mr. H. J. Patterson has been elected Director of the Maryland Agricultural Experiment Station, *vice* R. H. Miller, resigned. The State Legislature has appropriated $14,000 for the erection of a Science Hall, to be used jointly by the College and Station. It has also appropriated $10,000 for inaugurating State work in entomology and vegetable pathology, and has provided for an annual appropriation hereafter of $8,000 for its maintenance. C. O. Townsend has been elected Botanist and Pathologist in the College and Station and State Pathologist.

President Kellogg, of the University of California, has resigned.

Mr. J. M. Poor has been appointed instructor in astronomy in Dartmouth College, but we understand that Professor E. B. Frost, now of the Yerkes Observatory, will have supervision of the department and will spend part of the year at Hanover. Dr. G. H. Gerold, of the Dartmouth Zoological Department, has been given a year's leave of absence to be spent abroad, and Dr. H. S. Jennings, last year instructor in the University of Montana, will temporarily take Dr. Gerold's place. Other appointments at Dartmouth are: Dr. C. H. Richardson, to be assistant in chemistry and instructor in geology, and Mr. J. B. Proctor, to be assistant in mathematics.

Dr. E. Emmet Reid, of Johns Hopkins University, has been elected professor of chemistry and physics in the College of Charleston, S. C.

Dr. O. Brefeld, professor of botany at the Münster Academy, has been called to the University of Breslau.

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*DISCUSSION AND CORRESPONDENCE.*

AN UNUSUAL AURORA.

Last evening (September 11th) I witnessed at this place what I suppose to be an aurora, and which, if such, showed features so unusual as to seem worthy of record. The air was remarkably clear for the climate of this region and no perceptible wind was blowing. At $7^h50^m$ E. S. T. I walked out to a good point of view, free from artificial lights, to look for the zodiacal light and the 'Gegenschein.' I soon noticed in the south what I supposed at first to be a white cloud, which, however, soon disappeared. Later the supposed cloud repeatedly

reappeared and disappeared in so unusual a way that I watched it more closely. It was oval in form, the longer axis parallel to the horizon, bright in the central part and fading out gradually at the border. It filled the comparatively vacant space to the east of $\alpha$ Capricorni, and was perhaps five or six degrees in length. After some time I satisfied myself that it could not be a cloud from the facts that it did not obscure the stars, one or two of which were on its boundary; that it was, at brightest, twice as bright as the Milky Way; that it brightened up and disappeared again too rapidly, and was apparently almost fixed in position. In the latter feature and in its regularity of outline it also differed from any aurora I have ever seen. Toward the close of the exhibition it moved a little to the west, so that its last appearance was nearly central over $\alpha$ Capricorni. It last showed itself about $8^h30^m$. It must, therefore, have lasted in all at least 40 minutes, during which time it brightened up and nearly or quite disappeared again perhaps ten or twenty times. A noteworthy feature was that there was nothing like an auroral streamer and no aurora elsewhere, unless an extremely faint, fixed illumination of the sky along the north horizon was such.

Quite likely it was an auroral beam seen end on. If so, it affords one of the best opportunities that have ever occurred to determine the height and length of such a beam. I, therefore, describe the phenomenon in the hope that it may have been seen and its position noted in other parts of the country.

SIMON NEWCOMB.

HARPER'S FERRY, W. VA.,
September 12, 1898.

## SCIENTIFIC LITERATURE.

*Essays on Museums and Other Subjects Connected with Natural History.* By SIR WILLIAM HENRY FLOWER, K. C. B. London, Macmillan & Co., Limited; New York, The Macmillan Company. 1898. Pp. xv + 394.

Although the Essays on Museums form but a quarter of the bulk of this volume, they not unnaturally are accorded the first place on the title-page and form the opening chapters of the book. As Director in turn of the Museum of the Royal College of Surgeons and of the British Museum of Natural History, Sir William Flower has had an acquaintance with museums accorded to few, while his words have an additional value from the fact that he was practically the first to recognize the duties of a museum to the public and the important educational rôle it should be made to play. As he says: "The idea that the maintenance of a museum was a portion of the public duty of the State, or of any municipal institution, had, however, nowhere entered the mind of man at the beginning of the last century." And he might have added that there are some who still think the principal, if not the sole, object of museums should be the accumulation of material for the use of private individuals.

In this connection it is somewhat surprising to find the late Dr. J. E. Gray quoted as stating that the purposes of a museum are two: "first, the diffusion of instruction and rational amusement among the mass of the people; and, secondly, to afford the scientific student every possible means of examining and studying the specimens of which the museum consists."

"The first consideration in establishing a museum, large or small," says Professor Flower, "is that it should have some definite object or purpose to fulfil; and the next is that means should be forthcoming not only to establish, but also to maintain the museum in a suitable manner to fulfil that purpose. Some persons are enthusiastic enough to think that a museum is in itself so good an object that they have only to provide a building and cases and a certain number of specimens, no matter exactly what, to fill them, and then the thing is done; whereas the truth is the work has only then begun. What a museum really depends on is not its building, not its cases, not even its specimens, but its curator." And great stress is laid upon the fact that the care and administration of a museum, and its efficiency as an educational factor in a community, demands not only especial knowledge and training, but an inborn fitness for the work, and that these in turn are worthy of their due renumeration. In addition to skill, education, manual dexterity and good taste the museum curator should possess various moral qualifications not found in every professional man—punctuality, habits of

business, conciliatory manners, and, above all, indomitable and conscientious industry in the discharge of the small and somewhat monotonous routine duties which constitute so large a part of a curator's life." No one not familiar with the requirements of a large public museum could have put the case so graphically, nor would he have added: "Such being the requirements of the profession, what are the inducements offered to me to take it up as a means of livelihood?" And in answer to this Sir William quotes some examples of the 'inducements' offered, which in many cases are small enough, and to us, on this side of the water, where museum work is beginning to be better appreciated, even pitifully small. And, again, we read that "museums do not grow of themselves; money, time, knowledge and loving and sympathetic care must be expended upon them," and that "a museum must have an endowment adequate to defray its expenses and especially to ensure the staff of intelligent, educated and paid curators required to maintain it in a state of efficiency." All of which comes with unusual force from one who had drawn one of the few great prizes in museums, but who nevertheless realized the general inadequacy of museum salaries.

As regards the exhibition part of a museum the ground is well taken that the number of objects should be limited, but that every care should be taken in their selection, preparation and installation, and a plea is entered for the 'sadly-neglected art of taxidermy.' While it is to be borne in mind that this plea was made nearly ten years ago, it is a plea that will stand reiteration for some time to come. The advocacy of the concentration of type specimens in large museums will commend itself to all workers, for while it may sound well to have it said that this and that institution possesses such and such types the student can well appreciate the boon of having them concentrated.

Local, School and Boys' Museums are each the subject of an essay, and each contains many valuable ideas, while the concluding paper of the museum series, though first in point of time, is devoted to the history of the Museum of the Royal College of Surgeons. The evolution of this great institution from the collections left by John Hunter is described at length, and while the museum owes its existence to the untiring zeal and industry of Hunter, yet we learn that in housing, caring for and adding to the Hunterian collection the College of Surgeons has expended over $2,000,000.

In connection with the papers on museums Professor Flower pays tribute to the memory of Dr. G. Brown Goode, whose energy and devotion have done so much to advance the standards of museum methods in the United States.

Among the essays on subjects other than museums that on 'The Paleontological Evidence of Gradual Modification of Animal Forms' may still be read with profit, notwithstanding that since it was written, some twenty-five years ago, there has been a great accumulation of facts, especially through the labors of American paleontologists.

'Fashion in Deformity' will probably lead in favor among the anthropological papers, although all are interesting and instructive reading.

'Whales and Whale Fisheries,' the most recent of all, is a most admirable *résumé* of the subject; and the history of the southern whale fishery, now being repeated in the Arctic, shows well that no animal is too large nor its pursuit too difficult to prevent its extermination if only there is a little money in it.

While we can but regret the loss to science through the enforced period of restraint from active occupation noted in the opening lines of the preface, yet the bringing together and issuing of this volume of essays is at least some small compensation to the public.

F. A. L.

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## *NEW BOOKS.*

*Infinitesimal Analysis: Vol. I. Elementary: Real Variables.* William Benjamin Smith. New York and London, The Macmillan Company. 1898. Pp. xv + 352. $3.25.

*The Groundwork of Science: A Study in Epistemology.* St. George Mivart. New York, G. P. Putnam's Sons; London, Bliss, Sands & Co. 1898. Pp. xviii + 328.

*Die Chemie im täglichen Leben.* Lassar-Cohn. Hamburg und Leipzig, Leopold Voss. 1898. 3d Edition. Pp. vii + 317.